Computer Graphics

Computer Graphics concerns about anything related to the **generation or display of images** using a computer. Making graphs or setting fonts may be your daily engagement with computer graphics. Many people have more sophisticated tasks, for example, photo-realistic rendering, technical illustration, medical visualization, and many more. Games and movies are big investors in computer graphics.

Bitmap and Vector Images

There are two types of graphics. **Bitmap (Raster) images** are pixel based systems. They looks poor when you zoom in. They could already look poor without zooming in if you do not have enough pixels. With **vector images**, everything is mathematically represented. They have perfect quality, and look good even if you zoom in. Dynamic changes can be easily applied to an object in a vector image. They often have smaller file size compared to bitmap images.

With all the benefits, vector images requires human design from scratch, with other restrictions. The vast amount of images we meet everyday are more likely raster images. To understand bitmap (raster) images, first you should understand that a point on your screen is referred to as a PIXEL. **A Pixel means one Picture Element**. It holds a color value. The computer display, the "monitor", is made of a large number of pixels.

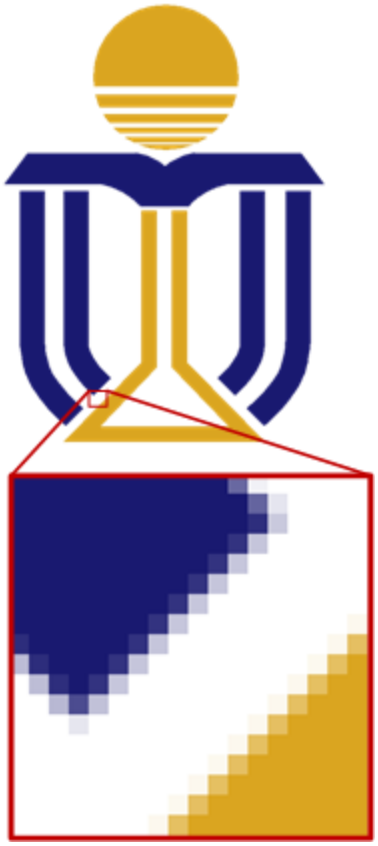
Resolutions

Resolution refers to the number of pixels in two dimensions. 800×600, 1024×768, 1280×1024, 1366×768, etc. are example **display resolutions**. The pair of numbers are first the number of columns, and next the number of rows. There are a few standard computer display resolutions for which people would design desktop wallpapers. The common resolutions nowadays are, standard HD = 1280x720, full HD = 1920x1080, and 4k = 3840x2160.

Resolutions are also considered in other representations. The resolution of a digital camera concerns the number of pixels that can be captured in total. For example, we may say I have a camera that shoots 9-Megapixel photos, or I have a 8-Megapixel camera on my smartphone. The resolution of printed material concerns the number of pixels—or “dots” per inch. The unit is *dpi* in short, e.g. 600 dpi. For the human eye, our “retina display” is approximately 326 pixels per inch.

We have higher resolution if we can fit more pixels in smaller size, then we will have more realistic and sharper images. You need to have "enough" resolution to start to realise the represented image. I hope you are able to see a girl in white holding a kungfu posture in the picture above.

Without resorting to a higher resolution, there are a few **techniques to enhance picture quality**, by "fooling the human eye". **Anti-aliasing** is a common technique. It works by using different shades of colors imitate smooth edges, hence reducing the awkwardness of jagged edges. It proves quite successful in approximating higher resolution, especially for text. Below is our university logo with the edges treated by anti-aliasing.

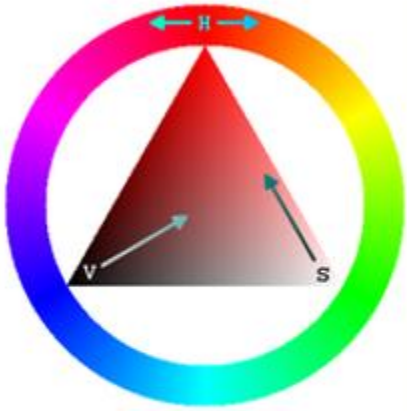


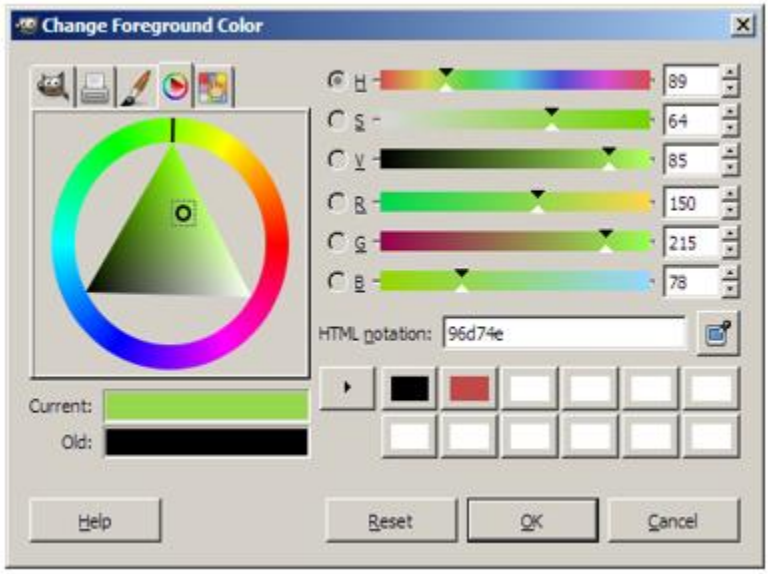
Color Representations

In the industry, there are a few **color representations** in use. For computer display, we would talk about the **R, G, B** values. The color of a pixel is represented by the "strength" of each of the prime colours **R**ed, **G**reen, and **B**lue. The three prime colors are built in the hardware of a monitor display. If you pour in 0 amount of red, 0 green, and 0 blue, you will get the black color. On the opposite, the white color is obtained by pouring in full values for RGB.

The number of colours that an image supports is called the **color depth**. The bigger the color depth, the more storage is required. A **true color picture** requires at least 24-bit of computer memory to represent one color value. 8 bit is used for each prime color. Multiplied together, it can represent more than 16 million colours. For a true colour image of 800×600 pixels, it requires at least 1.44 megabytes (3x800x600 bytes) of storage. This can hold close to 300,000 English words at the average of 5 letters per word! Below is the same picture rendered to different color depths. It shows a typical butcher shop in a Chinese wet market.

HSV is another color representation. It converts easily to RGB values, but its values are more human understandable, hence more useful to designers working with computer graphics applications. Its three components are: **Hue**—the position on the "color wheel" which distinguishes against all colors, **Saturation**—color purity which also means the difference from plain white, and **Value**—the intensity of the color. They are easier to relate visually as you can see a common design of an HSV colour picker below.





Other color representations include **CMYK**. It's a color representation for printing magazines and books against a white background. The three main components are Cyan, Magenta, and Yellow. They are the complements of the prime colors in paints. **CMYK means CMY plus the Black color**. In theory, you can get perfect black by mixing maximum C, maximum M, and maximum Y together. In

reality, you usually get a muddy black which is not really "black, black". So in the printing industry, there is the "black" ink which produces deeper black tone on paper. Also, when most text is printed in black, it saves paint to use a dedicated paint, other than mixing from other colors. CMYK is commonly used in ink cartridges or toner cartridges for a color printer, inkjet or laser alike.

Image File Formats

The development in computer graphics leaves us with a handful of image file formats, each with different strengths. The common file formats that you should be aware of are **.bmp** (Bitmap), **.gif** (Graphic Interchange Format), **.png** (Portable Network Graphics), **.jpg/.jpeg** (Joint Photographic Experts Group), and **.svg** (Scalable Vector Graphics).

Files in **Bitmap format** have names ending in .bmp. If your computer system hides file extensions, you should still see the description "Bitmap" associated with the file. This format attaches a color (R,G,B) to each pixel in 24 bits. It takes up quite a lot of storage space, as you can imagine a true color picture of 800×600 pixels will take up 800×600×24 ≈ 1.4+ MBs (conversion from bits to megabytes have been done for you). There is no animation, and it does not support transparency. Nowadays it is seldom used except for teaching image processing. People prefer its **compressed** versions into GIF or JPEG formats to save space.

The **GIF format** (.gif) stands for the Graphic Interchange Format developed in 1987. In its historical setting, it allows only 8 bits of color depth, ie. 256 colors. It is still true for GIF images you see today. It is a **loss-less** compression, that supports transparency and animation.

The **PNG format** (.png) is created by the Portable Network Graphics to replace GIF. It allows true color, while being a loss-less compression too. It achieves greater compression than GIF on most images. It supports transparency but not animation. So **the GIF format is indispensable with its animation support**.

The **JPEG format** is developed by the Joint Photographic Experts Group. It allows true color but it's a **lossy** compression, where the compression ratio may be specified. There is no animation, and it does not support transparency. It's designed for storing images produced by digital cameras in reasonable sizes while keeping acceptable visual appearance.

Scalable Vector Graphics (SVG) are the only vector graphics on our list. It is math representation and XML based. It effortlessly supports animation and interaction, and is suitable for game development. In fact, the math representation can be stored anywhere in the game program with innumerable ways, so probably you won't see explicit SVG files packed in your game's executable file.

A picture is worth a thousand words (or Bits and Bytes)! You will need good tools, coupled with artistic skills, and lots of patience to manipulate computer graphics.

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Canva Photo Editor

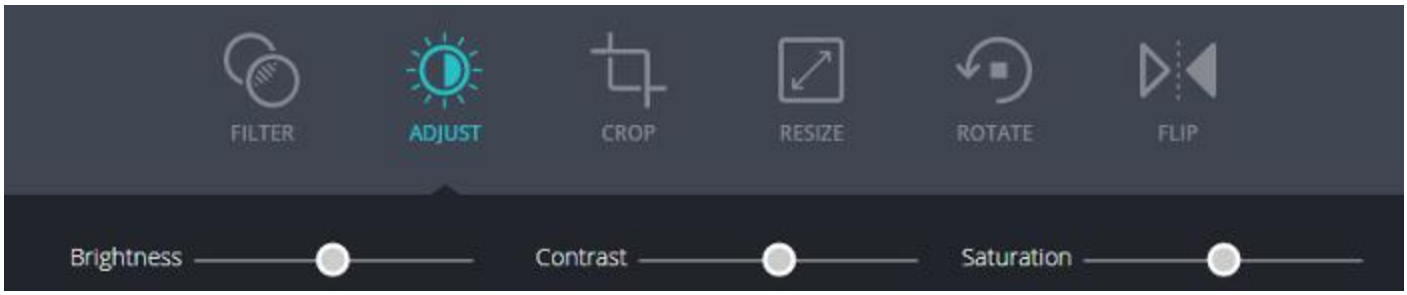
Canva is now a design school and it also makes money with its Canva for Work design tool. Revenue also piles up at its marketplace of design layouts and other elements. It started off by providing online design tools to make it easy for students and teachers to create yearbooks. As investors flocked to Canva, it's gradually introduced to the world. They have a simple but efficient photo editor that remains free of charge. You may also enjoy the design tool after signing up for free.

Canva Photo Editor

The Canva Photo Editor can be accessed at https://www.canva.com/photo-editor/ . You can try their demo image or upload your own to have a taste of a few essential skills in photo editing. Below is the appearance of the Canva Photo Editor. We will try with their demo image.

Brightness and Contrast

The first skills to try are the adjustment of **Brightness and Contrast**. You will see the adjustment bars after choosing ADJUST at the top pane. They are usually adjusted together.



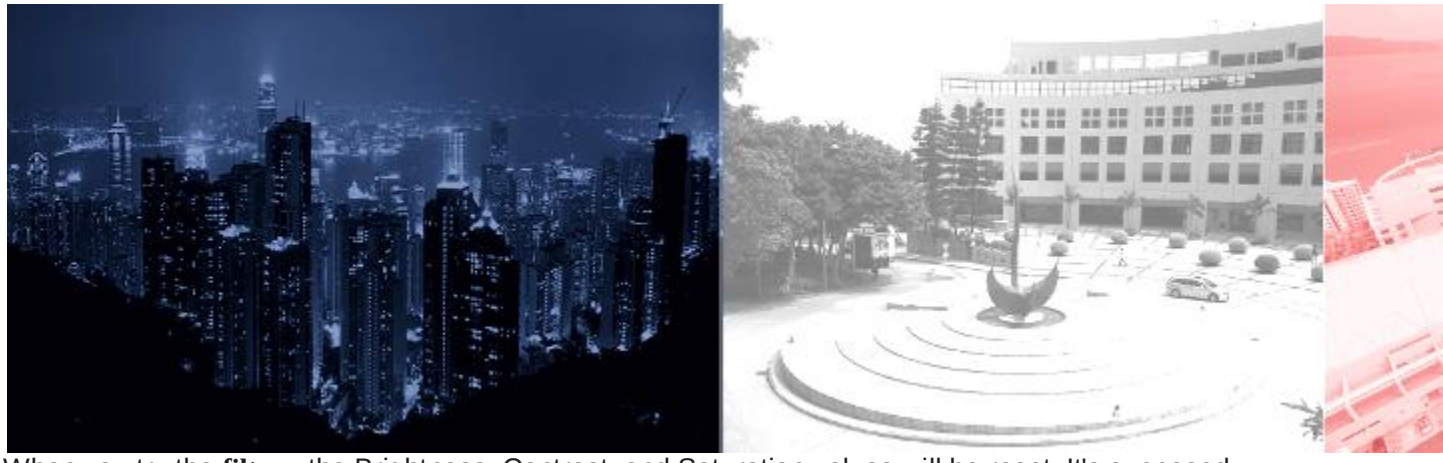
Try dragging the round handle to adjust the values of Brightness and Contrast respectively. Below are a few examples that have been treated by different combinations of Brightness and Contrast values. The left one is the harbor view of Hong Kong. The other two are pictures of our university, the Hong Kong University of Science and Technology.

It was unfortunate that the harbor view picture was taken on a misty day. Increasing the Contrast will help to "remove" the mist a little. It will be useful if you are from a humid country, or if you want to brush up your travel photos taken on a foggy day. Pushing the Contrast value further will a dramatic picture. Lowering the Contrast and tuning up the Brightness will give you a "bleached" photo that will be suitable as a background for your posts, with the least disturbance to your overlay content.

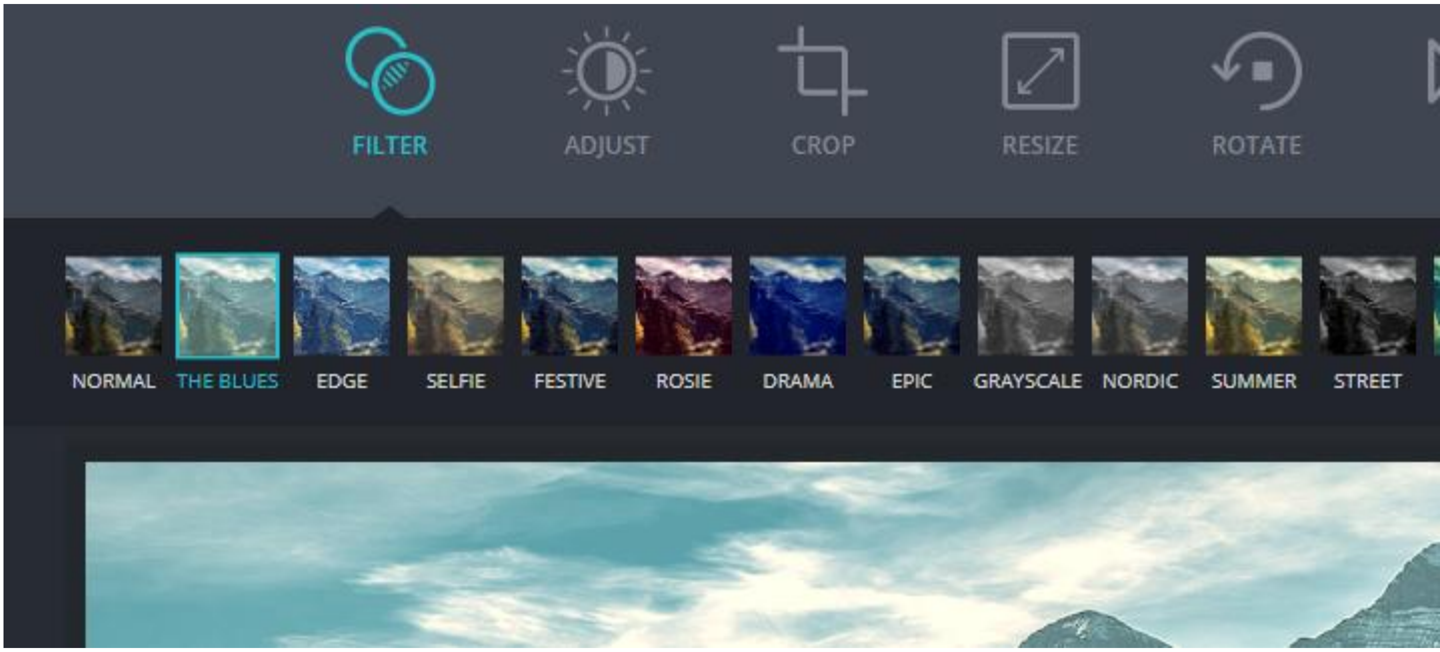
However, if your photo got as foggy as the below, I'm sorry that no photo editing operation could help you. You can download the photo (usually by right-clicking and choosing "Save image") and try.

Saturation

The commonest operation on the Saturation value is to set it to **zero** completely, which then gives you a picture with all its colors mapped to the **grey scale**. At first, it gives a retro feeling when there were only black and white photos. Then, you can combine it with color filters to produce pictures of special color tones that will match your design.



When you try the **filters**, the Brightness, Contrast, and Saturation values will be reset. It's supposed that you choose a filter first (if you want to), and adjust the values afterwards.



In fact, the order of the tools suggests the desired order to edit your photo. You should use the tools from left to right. So after you finish with the filter and adjustments, you can crop your photo and resize to a just enough size. When you post your photos online, or apply to your web blog, you do not need more pixels than you will display. Downsizing your photo will help you save storage and promote transfer speed.

Finally, click the big green **Download** button to save the photo to your computer in PNG format by itself.

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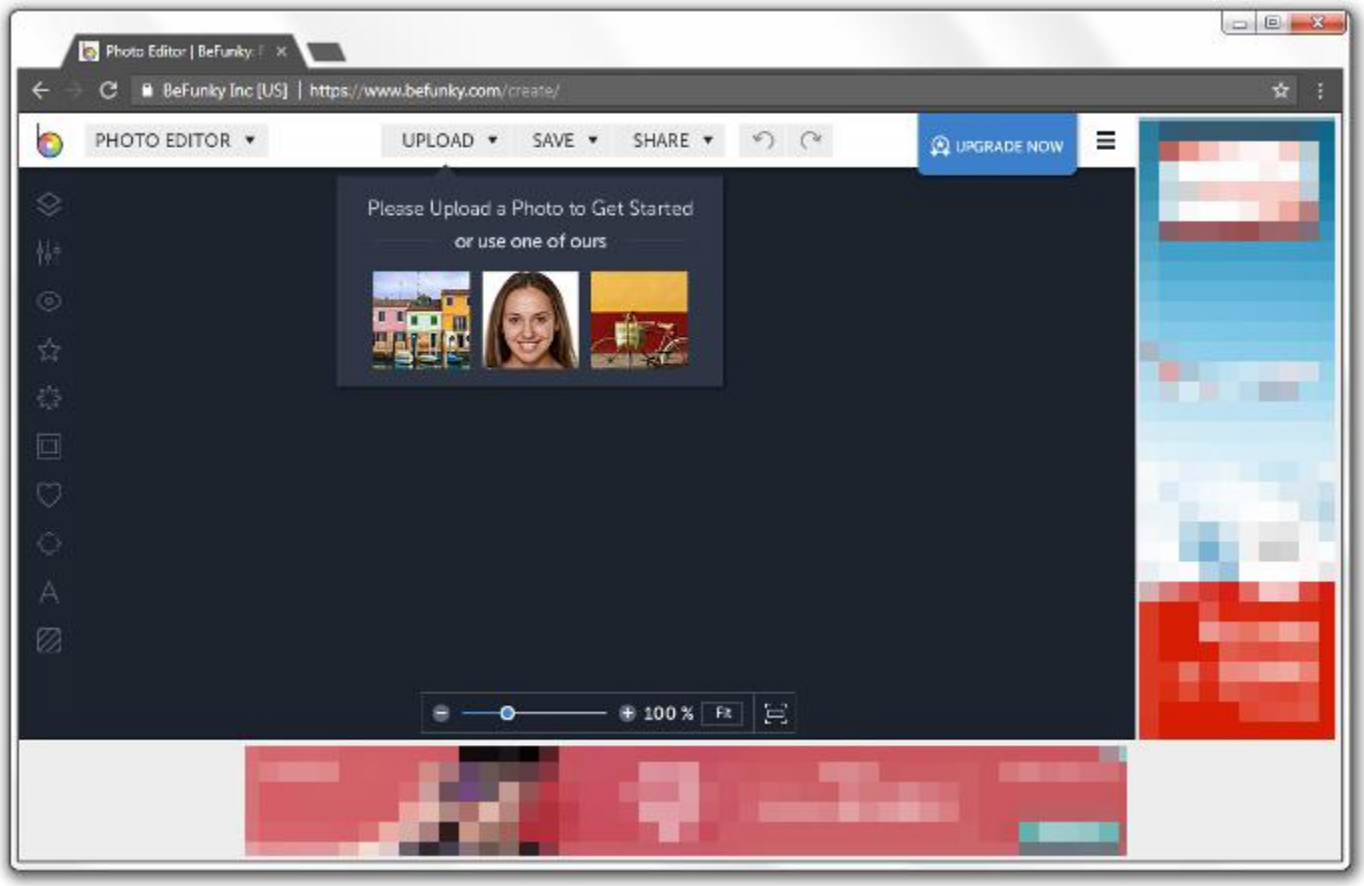
BeFunky Photo Editor

BeFunky posits itself in an era where every photo can be easily re-created with photo editing apps that add more feeling, creativity, and meaning. It is a hub of Photo Editor, Collage Maker, and Designer apps that comes free of charge for a range of functionalities. The other paid features are also displayed alongside, and you could select to preview the effects.

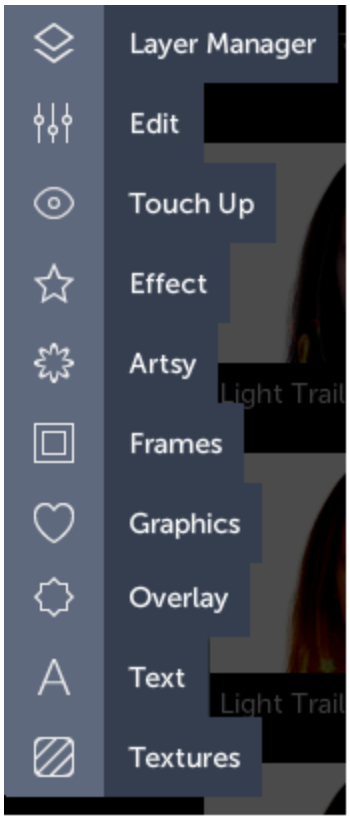
It supports saving to computer in JPG with adjustable compression rate or in PNG. JPG will be a good choice if you are editing photos. PNG will be the best if you are creating graphics with their Designer app.

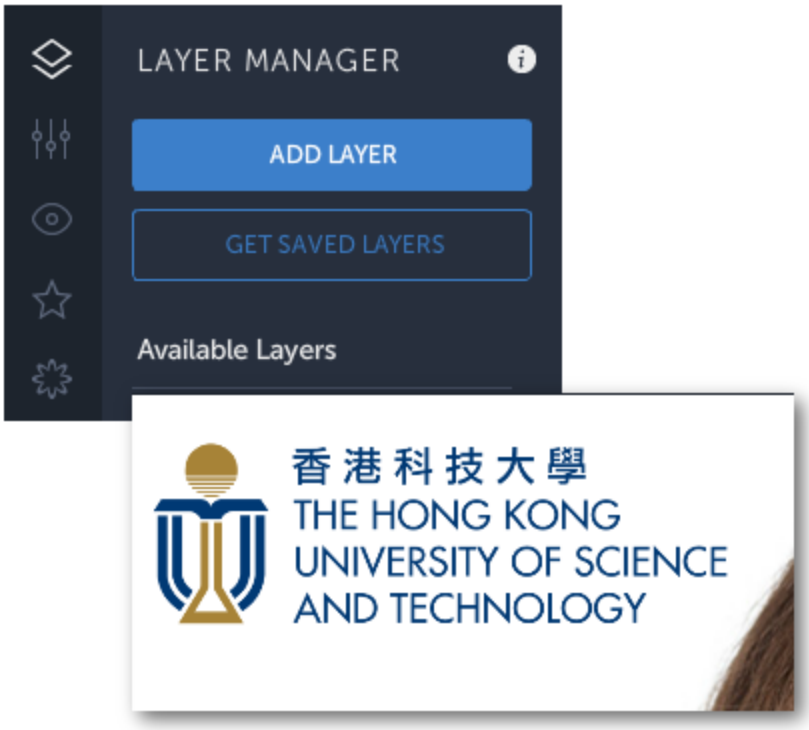
BeFunky Photo Editor

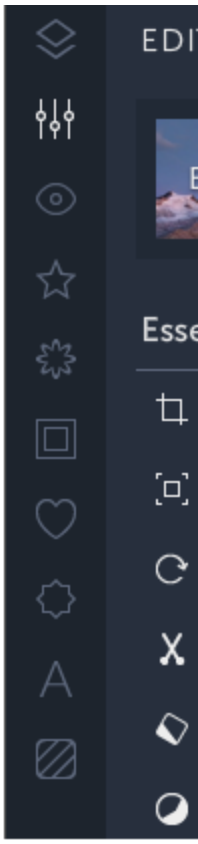
The BeFunky Photo Editor can be accessed at https://www.befunky.com/create/. This website requires Adobe Flash to run. The free version shows advertisements, which we have "treated" in the screenshot below. You can try with their demo photos or upload your own.



Below is an overview of the tool categories. **Layer Manager** will be helpful for adding a watermark to your picture, which is a common practice to add a signature or logo and also to prevent unauthorized usage of your picture. **Edit** contains the essentials operation with more advanced settings than the Canva Photo Editor. The paid contents are marked with the "PLUS" icon.

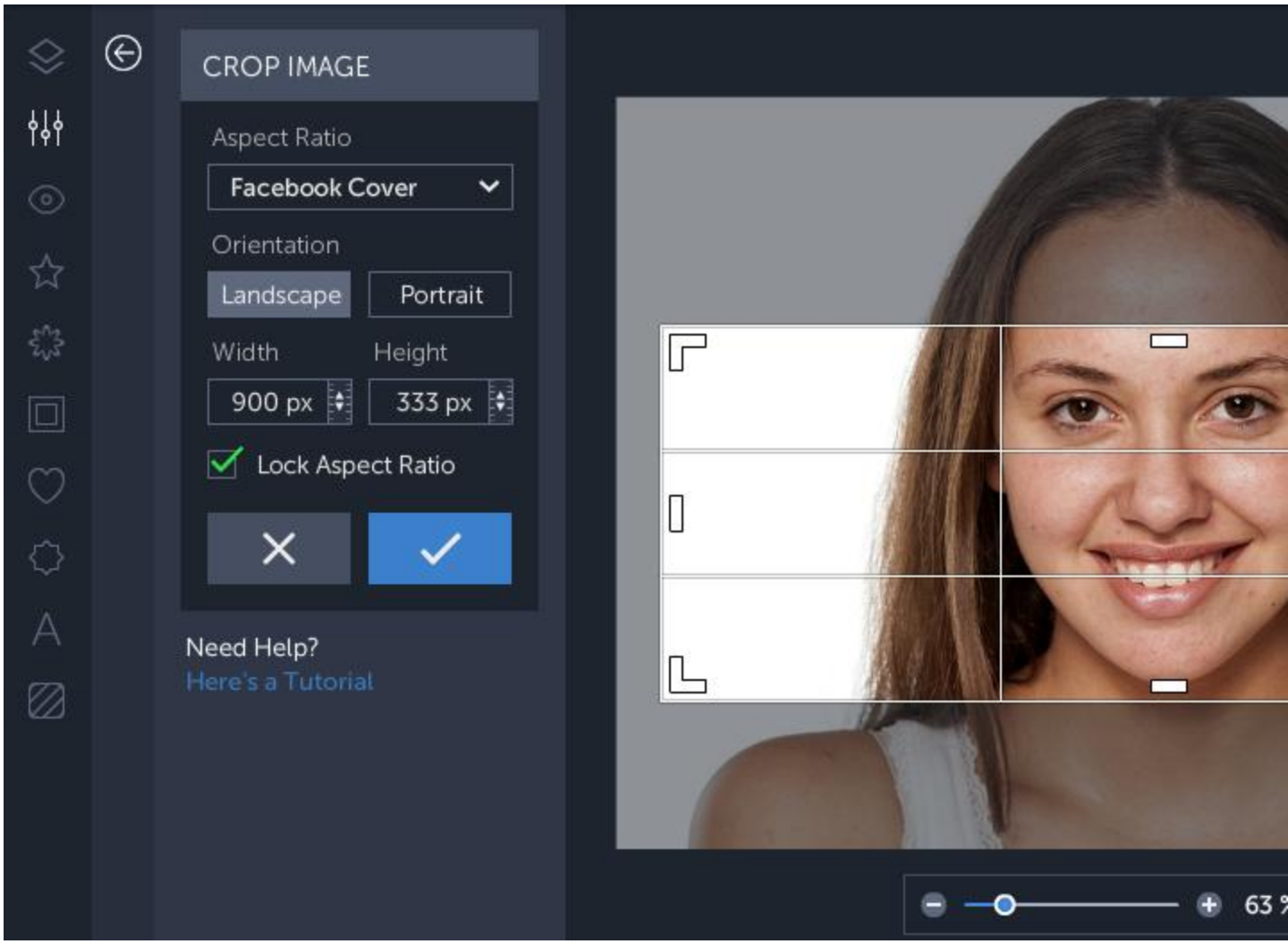




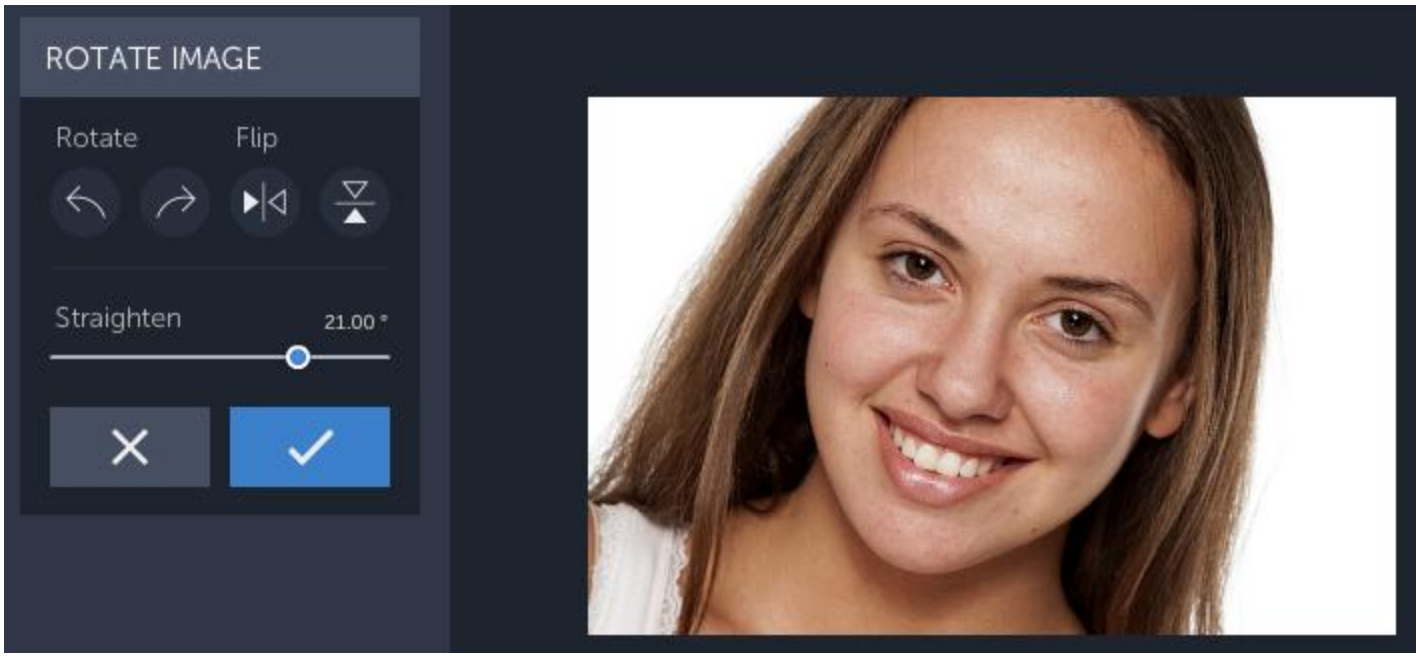


Crop and Rotate

In particular, the **Crop** tool in BeFunky needs more mentions as it provides the option to crop the image to the aspect ratios that fits the popular social media.

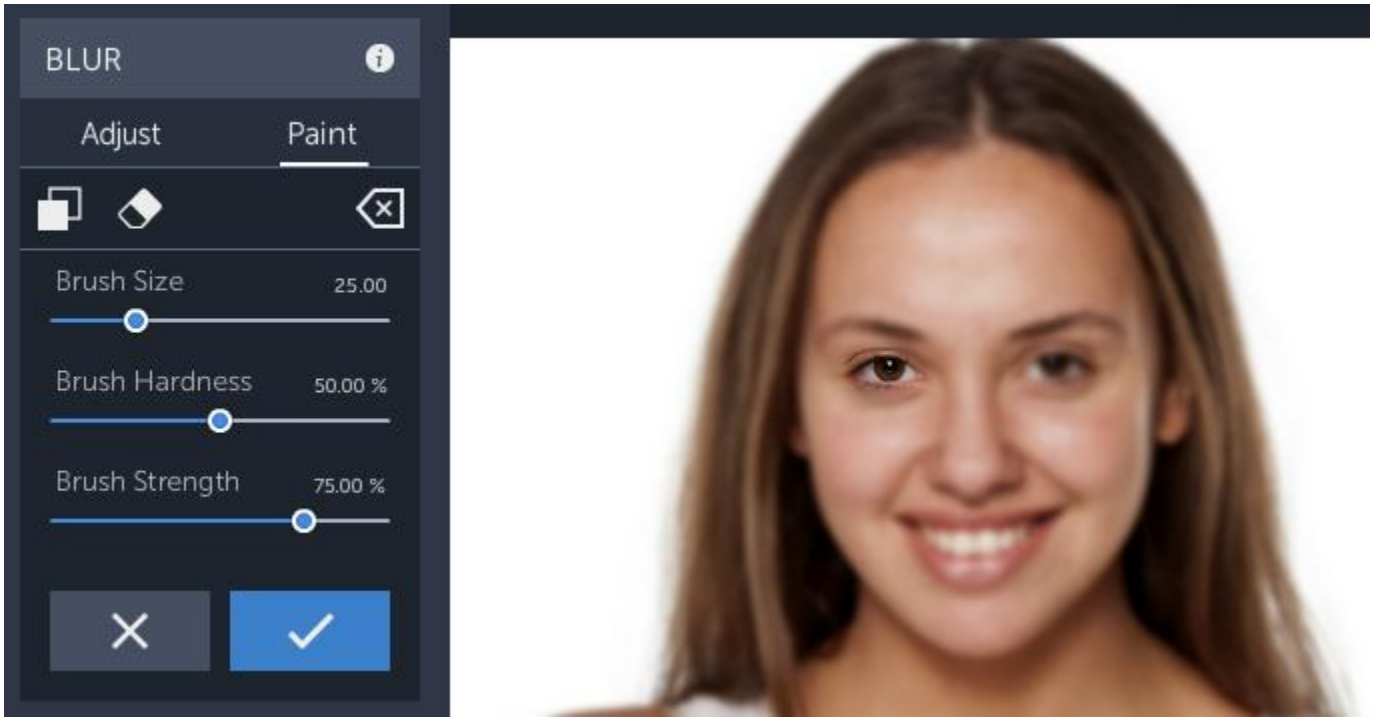


The **Rotate** tool is also more powerful. It allows you to straighten the image if it was not framed well when taken.



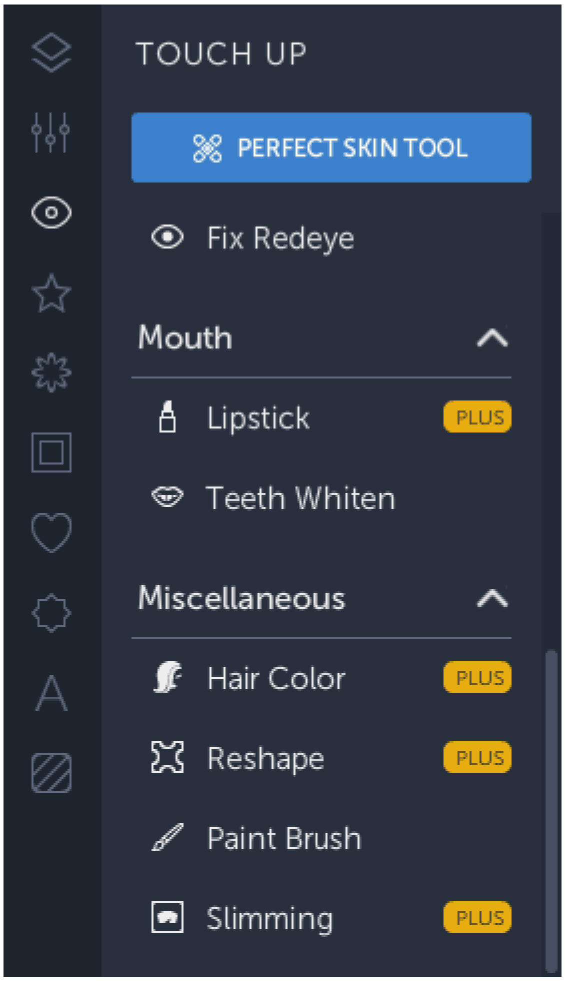
Advanced Operation with Blur

The **Blur** tool is available free of charge. Furthermore, it is built with easy operation for interesting effect. After setting the desired values in the **Adjust** tab, you can switch to the **Paint** tab and "unblur" certain area by using the mouse to "paint" on it. It will produce a focus point for your audience. The below picture is treated by "unblurring" the right eye of the model.



Touch Up

Most of the **Touch Up** tools are paid features. Among the free features, you are recommended to try the **Teeth Whiten** tool. Be careful that it will bleach any area you brush on, not just the teeth!



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Introduction and Installation

Open Source, Portable Apps

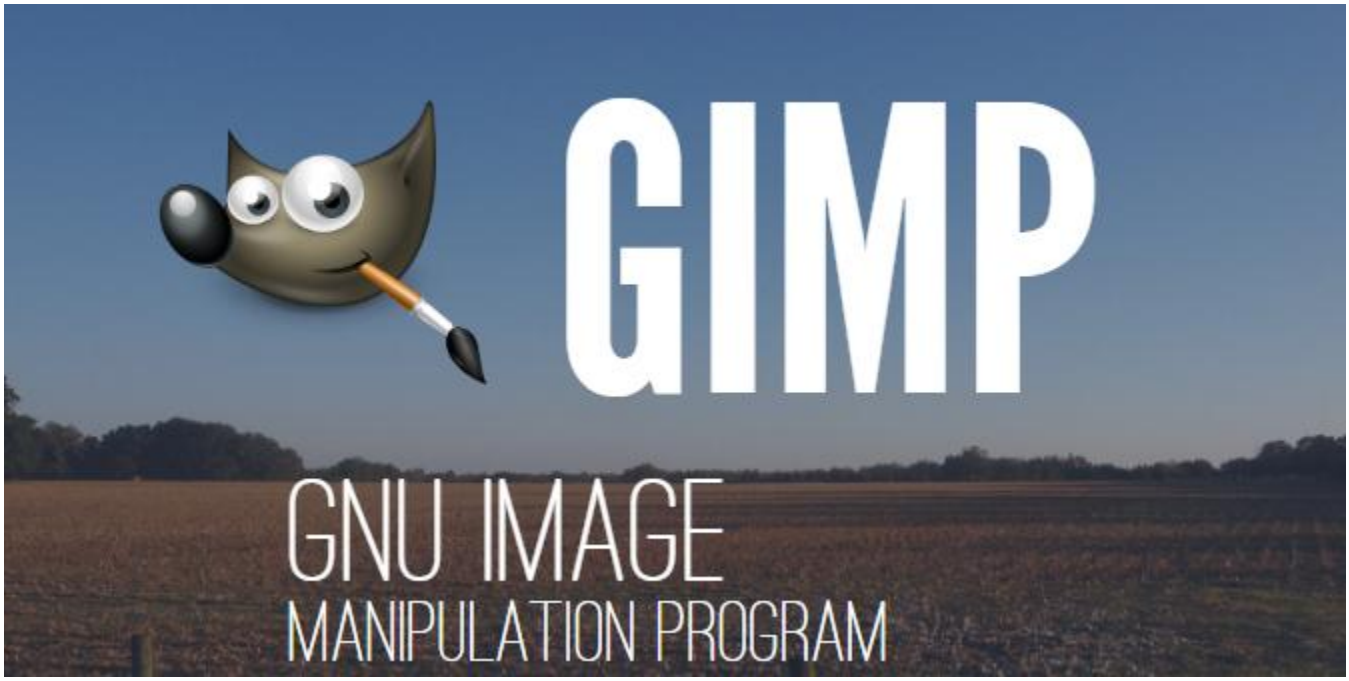
Free software is around to cope with a wide range of computational needs. Some others come with a trial period that once expired it will no longer function unless you pay a price, or as a trial version that only demonstrates the basic function. Still, a lot of small useful tools remain free of charge throughout. The truly free software, however, is the **open source software**. You do not just use it, but you can also develop it to suit your own preference—if you know how. Many of the world's most successful open source projects have their roots in the academy. Some are distributed free of

charge under the promise of enterprises to drive innovation that is required to optimize how the company creates, deploys, and uses its software assets. The open source initiative is rewarded with higher quality, greater reliability, more flexibility, and lower cost. MIT App Inventor is an example of open source applications for developing Android applications from beginner levels.

Paid software usually asks to be installed. First, it is because they are usually larger, to worth the price. Second, the installation process checks for the proof of a valid purchase. Sometimes you just need to rely on a public computer, but you can never install your choice of software on it, as you don't have the administrator permission. "**Portable Apps**" are software used with no installation, while keeping all personal settings you saved. It is made possible by residing the software in your USB flash drive.

GIMP Installation

GIMP, short for GNU Image Manipulation Program is a free and open source program by Peter Mattis, Spencer Kimball, et al. It also came with many professional features. At times, it's praised to be the free counterpart of Adobe Photoshop. You can assess the latest version at https://www.gimp.org/.



GIMP requires installation for better performance, and its installation only requires low privilege so probably you won't need to ask your parents for installing it on your family computer shared with sisters and brothers. If you want to use it truly anywhere, on public computers too, you will also find a solution. Some other folks have made GIMP, which is open source, into a portable package that can be installed in your USB flash drive. Check out PortableApps.com for a download for Windows!

Project Files

GIMP saves to a different file type that can only be used with GIMP. It is used to record the editing information such that you can continue to work on the manipulation. It is also the approach of the famous Photoshop software. They also have their own project file. Then of course, you can export to the common graphics file types for viewing in any browser or image viewer.

Project File (.xcf)	**Product File (.jpg, .gif, ...)**
Can be viewed and edited in GIMP **only**	Can be viewed in **any** browser or image vie
Editing information (e.g., selection, layers) **preserved**	Editing information **lost**

To open, save, or export files, look into the **File menu** in the application.

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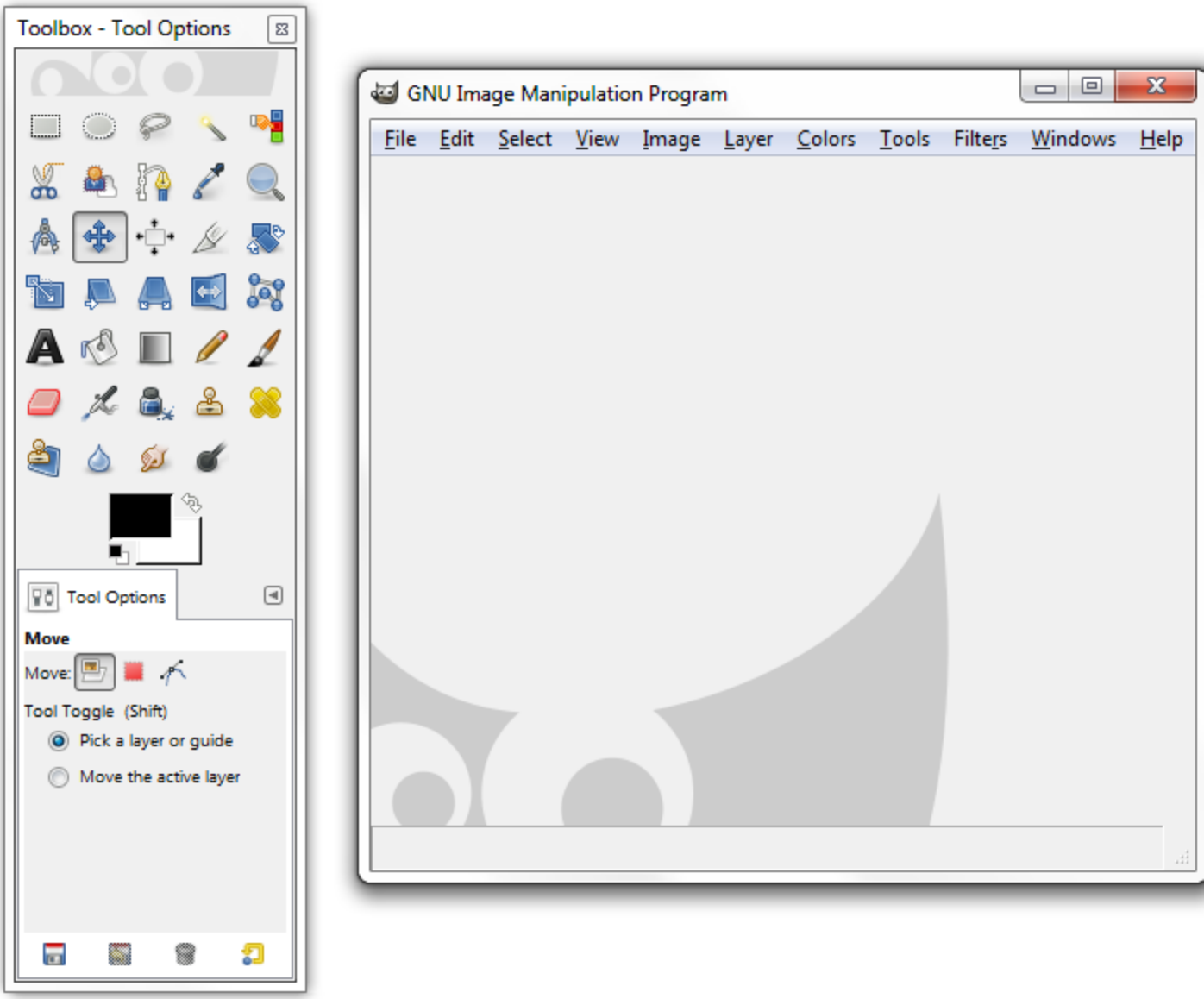
MmmInterface and General Operation **GIMP**

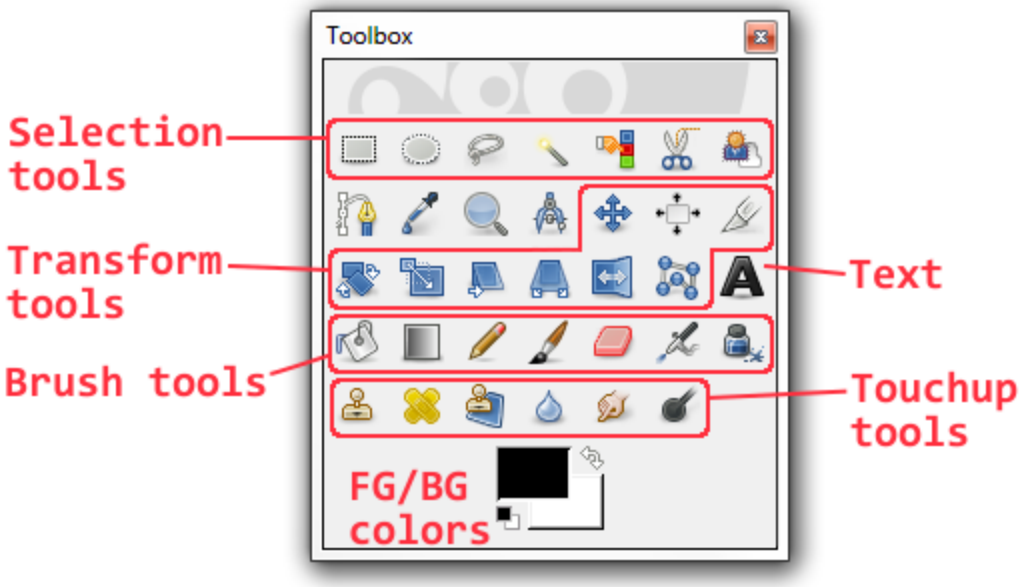
The general interface of GIMP looks like this:



The **middle part is the main program**, where you can drag picture onto it to open for edit. The two things on the sides are **dockable dialogs**. It is a common mistake for beginners with GIMP to close a dock when it is intended to close the picture. In that case, you can find them under *Windows » Recently Closed Docks*. You may not need the **Layers** dock right now, but surely you wouldn't want to lose the **Toolbox** dock.

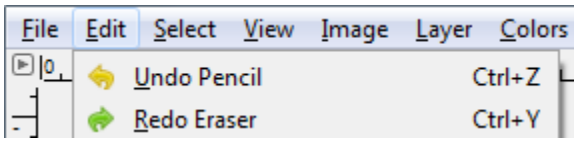
Toolbox

The toolbox dock lists out the operations that would best be done with your **mouse**. Of course, with Canva and Befunky, you also drag the controls with your mouse, but those operations are just adjusting values within a range. They could be down with hot keys and keyboard input—if you know how. In photo manipulation, there are a lot of operations that requires **precise pointing and selection** that makes the mouse indispensable. Selection of an image area in computer graphics is much more difficult than selecting text in a digital document. The toolbox is a collection of such operations.



The tools in the toolbox can be roughly classified as above. You can see **selection tools** has its own family. You've got to pick a different tool to suit the situation for the best selection result. **Transform tools** cover operations from moving to deforming a selected area. The **text** tool allows you to add text to anywhere, just like the red text we added above to explain the different tools. **Brush tools** are used to add colours. **Touchup tools** are used to clear blemishes. **Foreground and Background colors** apply to all tools.

Undo and **Redo** are important operations when you try out different tools and operations. Gradually with repeated usage you will learn to use it with the **hotkeys**, ie. Ctrl+Z and Ctrl+Y.

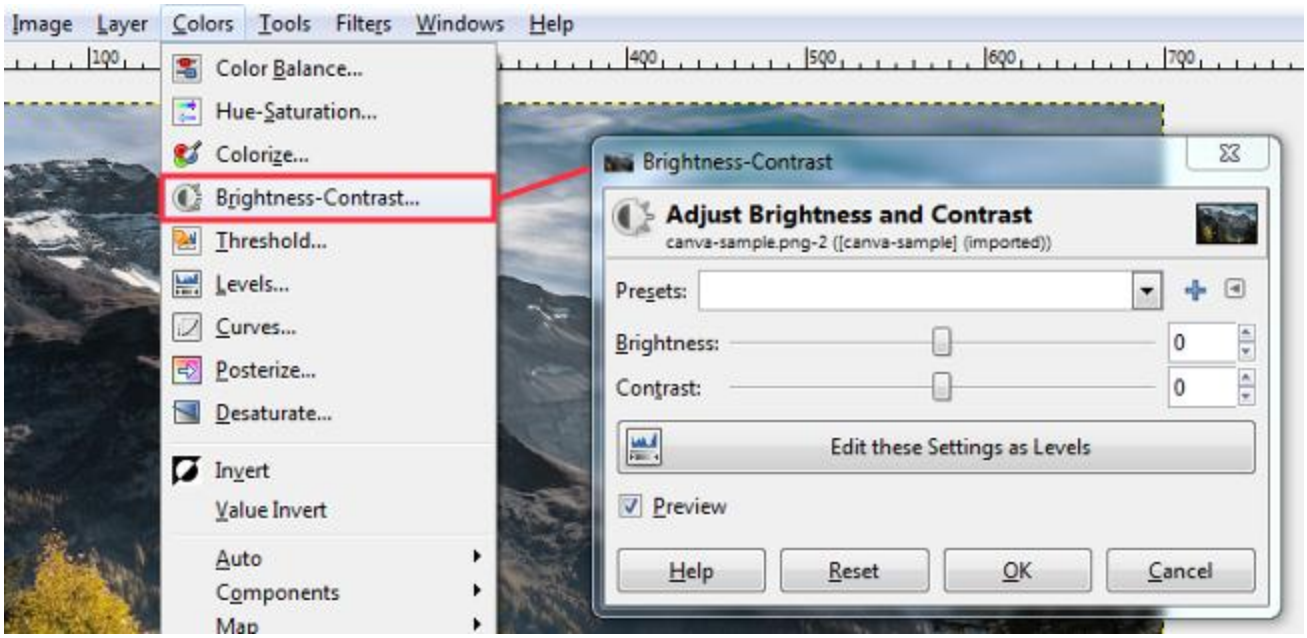


Repeat the Tasks Done in Canva and Befunky

What we did on the online photo editors Canva and Befunky can be done on GIMP of course, with different procedures. Let's recall that we've adjusted Brightness, Contrast, and Saturation in Canva, and we played with Blurring (part of) an image in Befunky.

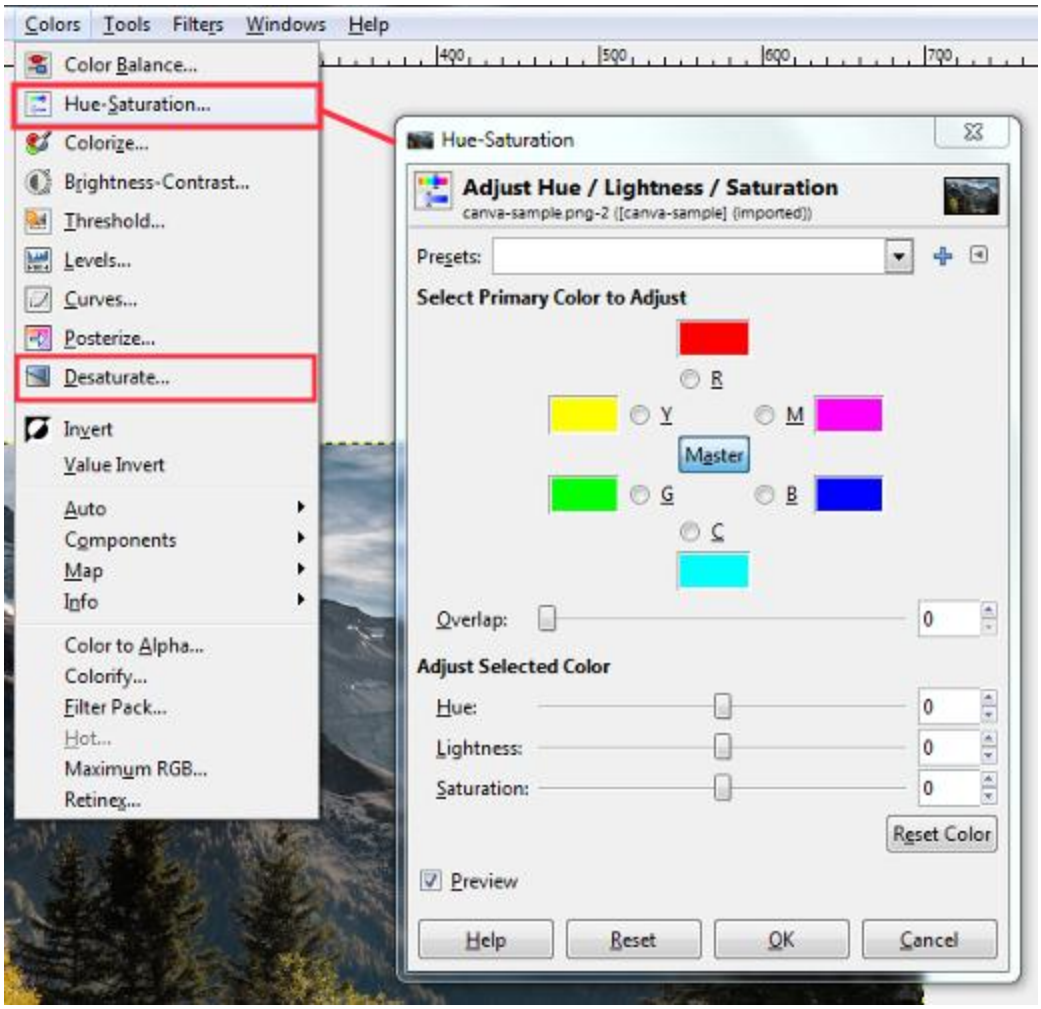
Brightness and Contrast

To adjust the Brightness and Contrast in GIMP, go the **Colors** at the top menu.



Saturation

Saturation is not a separate adjustment in GIMP, it is adjusted with other values. Go to **Colors** again, and find the **Hue-Saturation** operation. At first, the **Master** color is select, meaning that adjustment will be applied to all color pixels in the image. It is possible to adjust the values for one of the prime colors or their complements. It may be utilised to make the green grasses or the blue sky more vibrant.



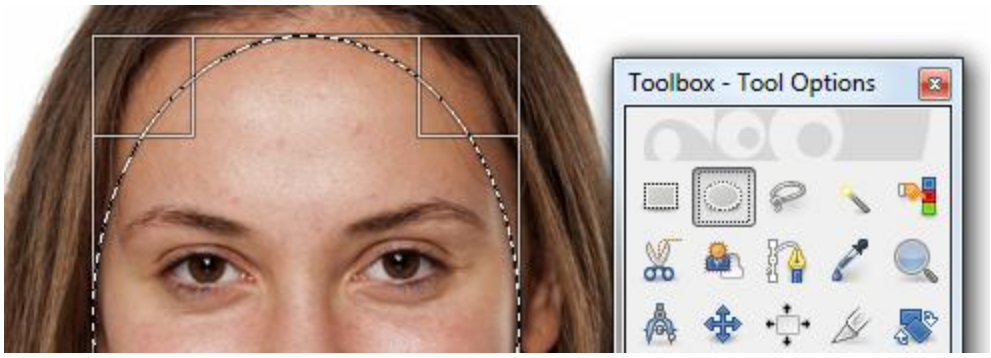
Desaturate is a quick

Blur a selected area

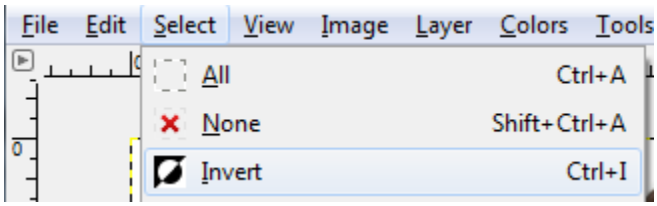
Several Blur operations can be accessed at the **Filters** > **Blur** menu. The commonest choice is **Gaussian Blur**, which gives a good imitation of losing focus, with simple options to adjust. Now undo the Blur and try it again after the following steps.

To "clear the effect" for a selected area like Befunky, we will need more steps.

In fact, we do not clear the effect in retrospective. We would rather avoid selecting certain area, such that the effect will not be applied in the area in the first place. For example, we want to blur the Befunky sample human portrait photo, but keep the face sharp and clear. In effect, we want to **select "everything except the face"**, but it is difficult to do, so we will do it the other way round. First we would select the face with the **oval selection tool**.



Next, **invert** the selection by going to **Select** the menu.



Although you may not be able to notice any difference before and after the selection inversion, you will see it when you apply the Blur filter.

Enjoy editing!

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Question 1
In GIMP, why would we want to save to XCF files instead of into JPEGs, GIFs?