

USER GUIDE FOR NIMP

by

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USER GUIDE FOR NIMP

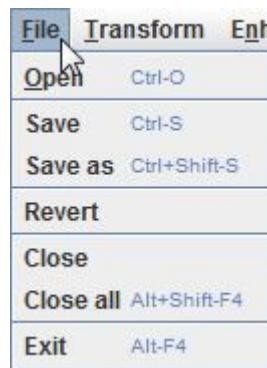
The features supported by this Image Manipulation Program can be broadly categorized into three types as is done in the menu system.

File Transform Enhance Apply Effect Help

Figure 1 Menu Bar of NIMP

1.1 File

The first menu item, File contains a set of basic commands to handle image files. When File menu is clicked, a sub-menu is shown with features that allow an user to load an image file for editing or to save changes already made to the image. The File menu can also be opened by pressing “ALT+F”.



**Figure 2 File Menu
of NIMP**

The commands available in the File menu and their purposes are explained below.

1.1.1 Open

This function can be accessed by clicking File and then Open. This function allows the user to select and load an image to be edited using the program. Once this menu item is chosen, the user will be prompted with a file browser to select an image to open.

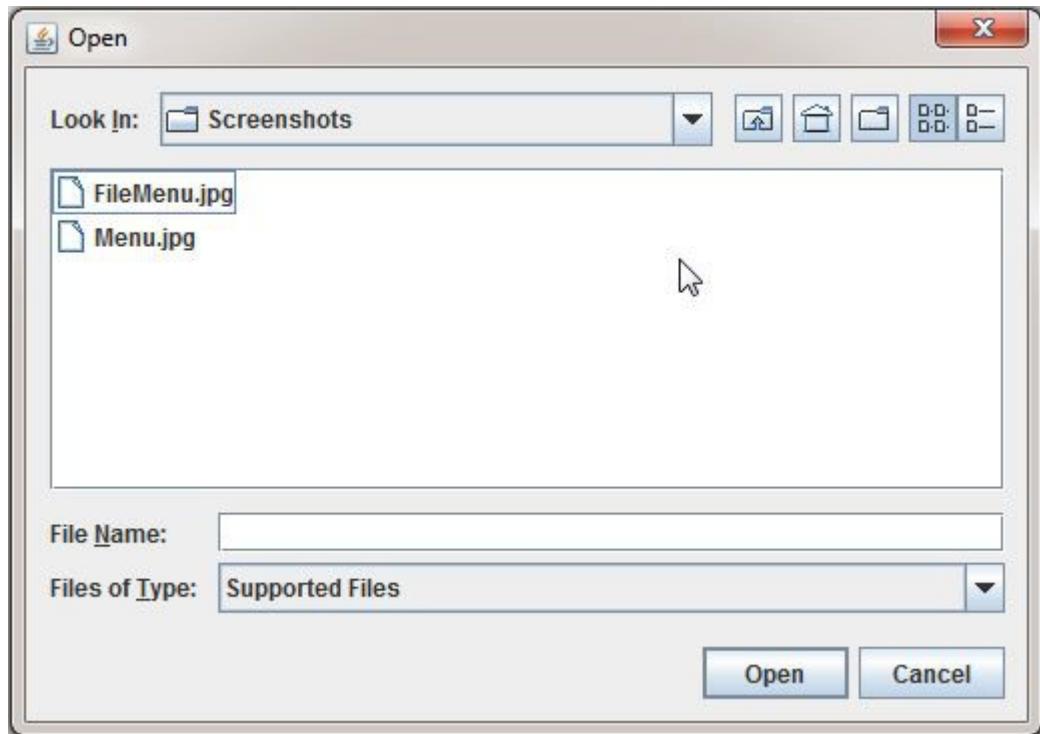


Figure 3 File Browser for Opening a File with NIMP

The user then has to browse and select a file and then click open to load the image. By default, the application filters the files in a given folder and shows only standard image formats supported by the application. This also filters out image files in a standard format that do not possess a file extension. The “.raw” file type is not a standard image format. And, so, only gray-scale “.raw” files of the dimensions 640 pixels width and 480 pixels height are supported. In order to open such files, the user has to click the combo box in front of “Files of Type” and select “All Files” as filter.

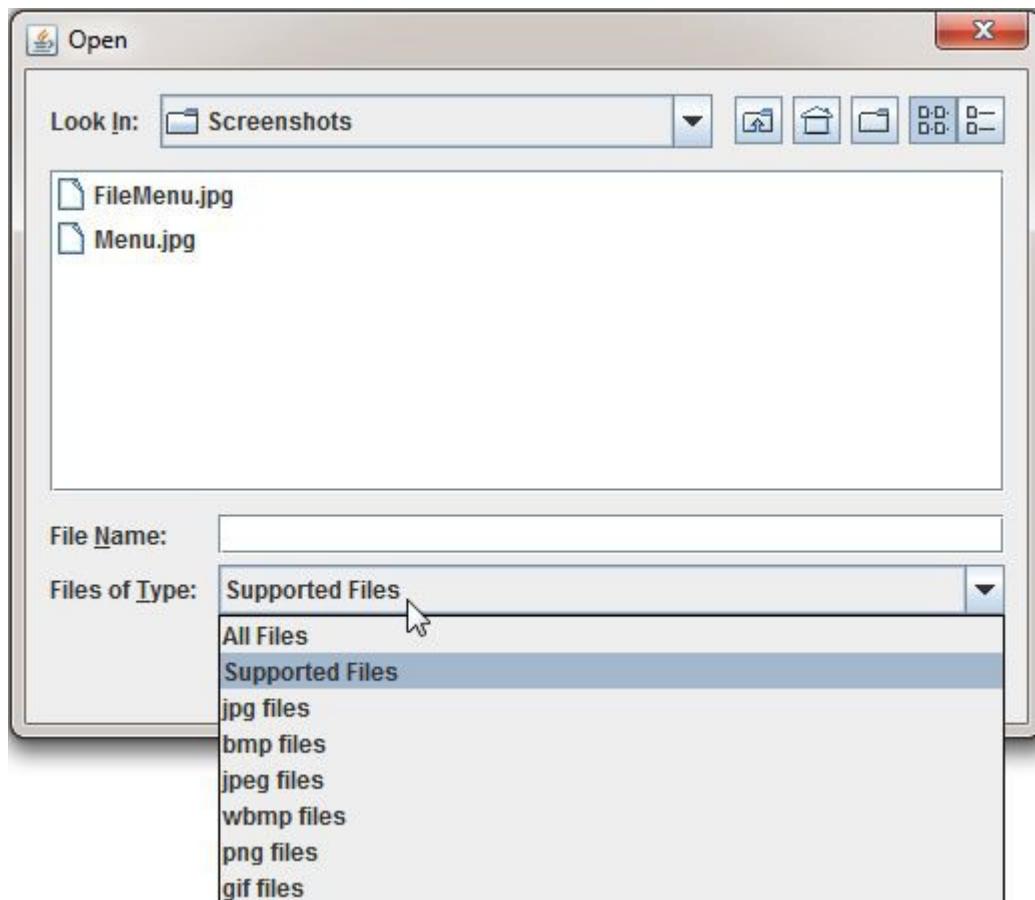


Figure 4 Changing File Type Filter when Opening Images

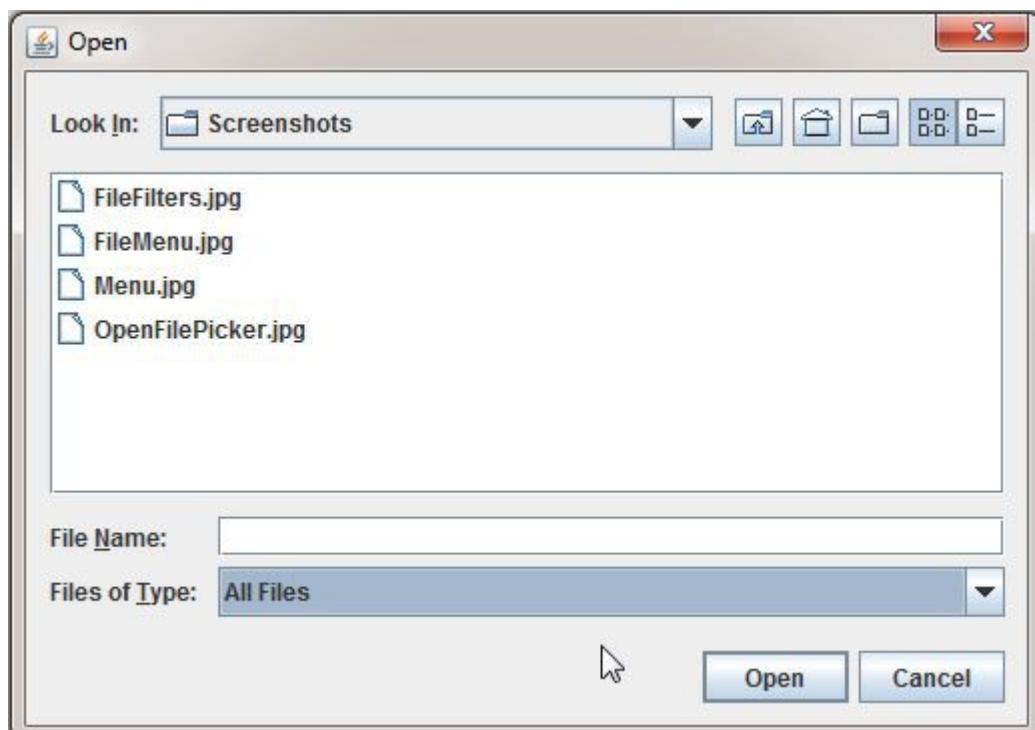


Figure 5 Viewing All File when opening an Image

The user can also select a particular file type from supported list in case too many files are present in a folder. When using “All Files” filter, the user will also be

allowed to select non-image files. If user selects a non-image file or an unsupported image file, the application will show an error.

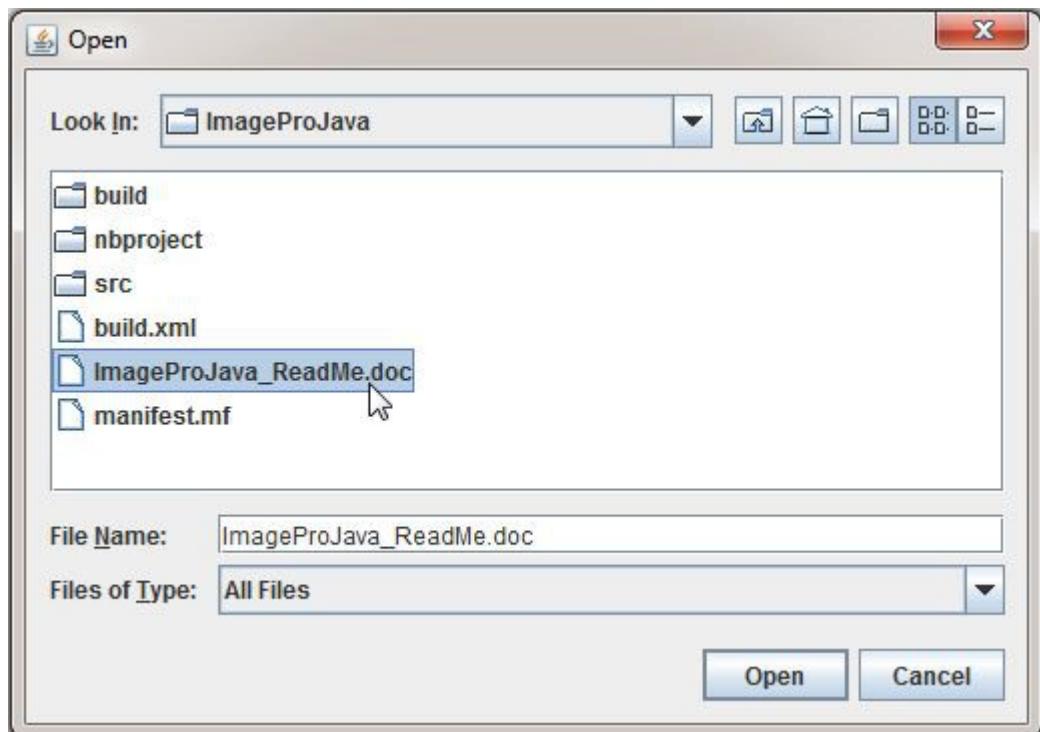


Figure 6 Attempting to open a DOC file

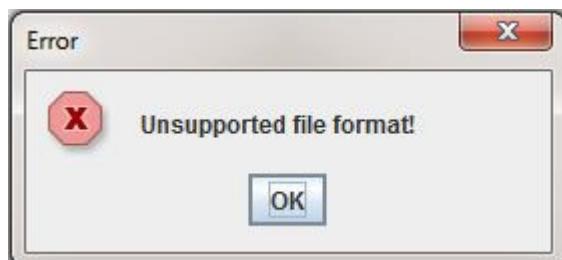


Figure 7 Unsupported File Format Error

This command can also be accessed by pressing ALT,+F and then O or by simply pressing CTRL and O simultaneously.

1.1.2 Save

This menu item can be accessed by clicking File and then Save or by pressing ALT+F and then S or by simply pressing CTRL and S simultaneously. Executing this command causes the program to save any changes that were made to the image to the same file which contained the original image. Once changes are saved, the

original file cannot be recovered unless the user saved a backup copy. Hence, the application will prompt the user to confirm their intention.

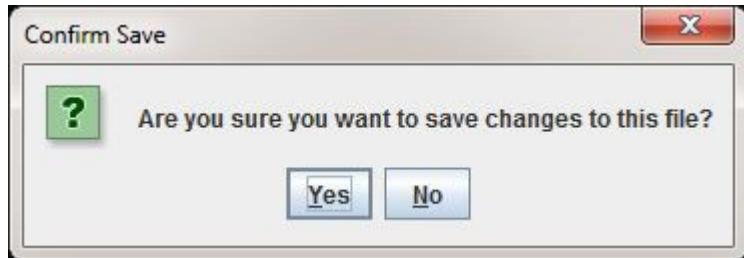


Figure 8 Prompt to Confirm when Saving Changes

The changes will be written to disk only if user clicks Yes. Otherwise, original file will be left intact with no changes.

1.1.3 Save As

This menu item can be accessed by clicking File and then Save As or by pressing ALT+F and then A or by simply pressing CTRL, SHIFT and S simultaneously. Executing this command allows the user to save any changes made to the image to a file. However, as opposed to Save command, once user executes this command, user will be prompted to choose the location, name and extension of the file with a file browser as below.

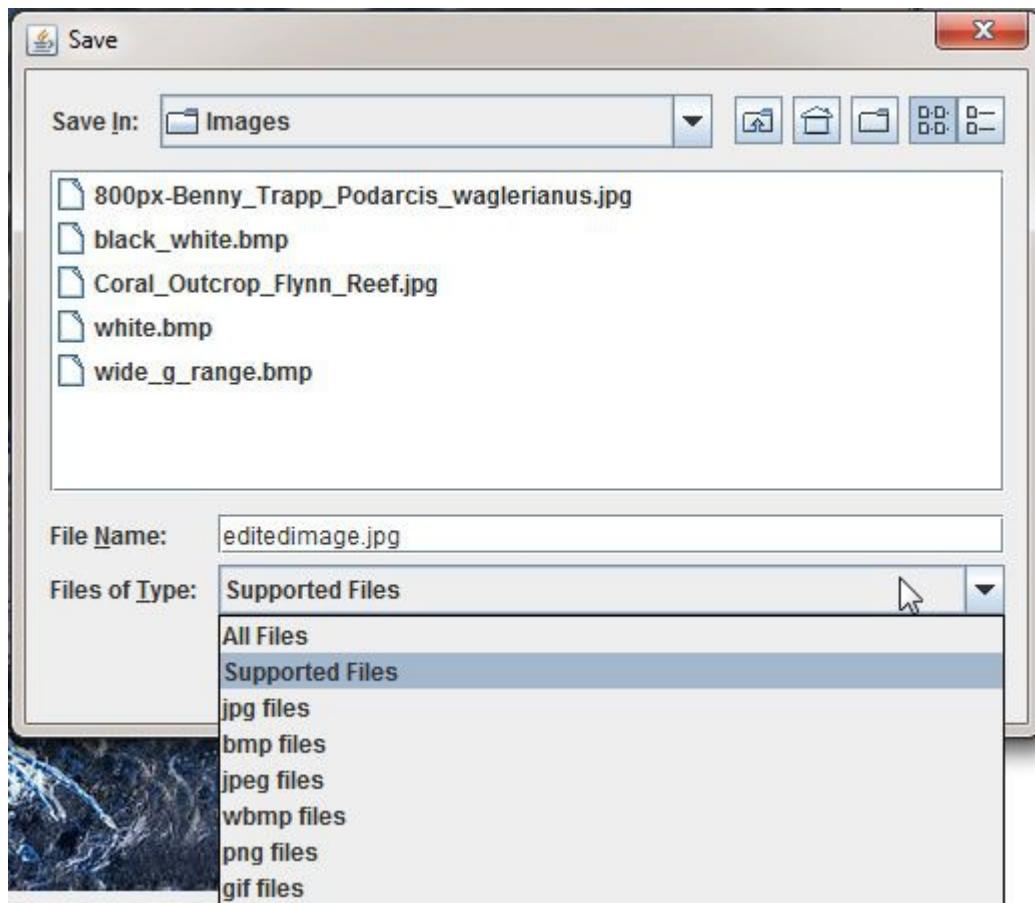


Figure 9: Save As Window

However, user will be required to specify a valid image file extension or choose an image file format using the “Files of Type:” drop down box. If user does not specify using one of the two options, an error will be shown.

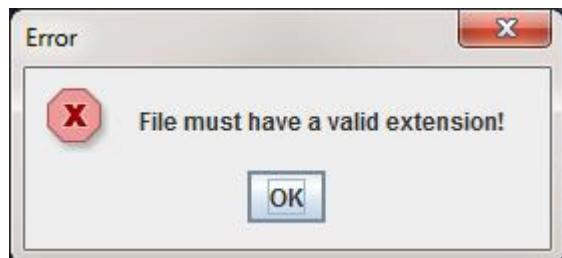


Figure 10: Error when a File Extension is not Specified for Save As

If user specifies an extension manually and also selects an image type using “Files of Type:” option, the extension specified in name will be considered as part of name and the type selected in drop box will be used as the actual extension.

For example, if user types test.jpg in File Name and selects png in “Files of Type:” as shown below, the file be saved as test.jpg.png (Name is test.jpg and file type/extension is png).

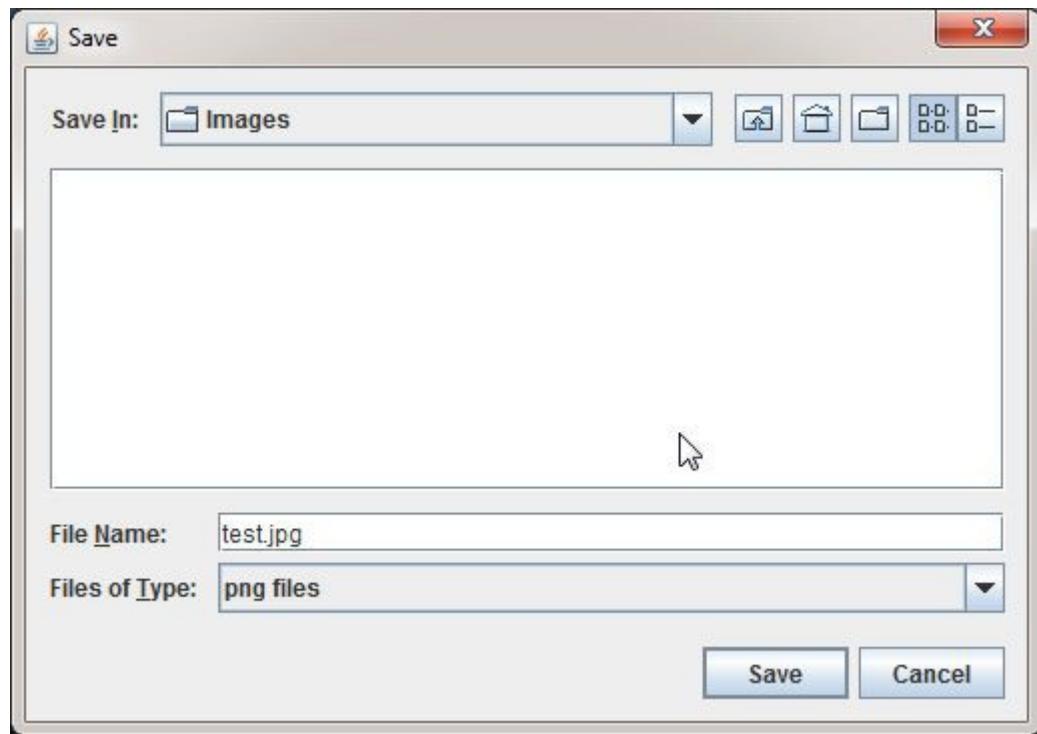


Figure 11 Conflicting Extensions when using Save As

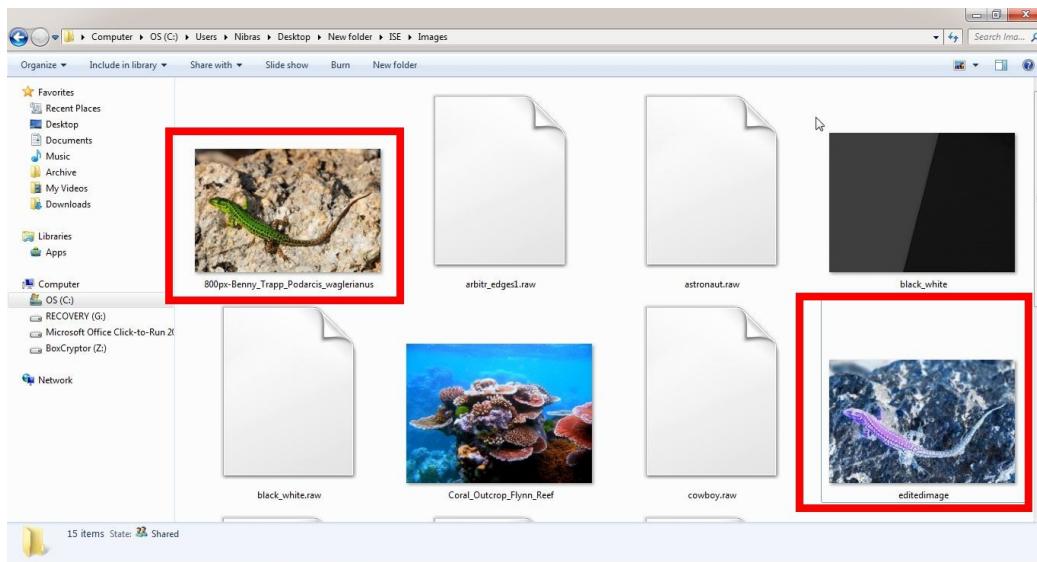


Figure 12 Effect of using Save As (Podarcis waglerianus (n.d.) and A variety of corals form an outcrop on Flynn Reef (2010))

As shown in the screen-shot above, if user uses Save As option and specifies a separate name, the edited file is saved with a different name leaving the original application intact.

1.1.4 Revert

Currently, the program does not support Undo and Redo functions. However, the program supports revert. This allows the user to discard all changes that were made to the image since it was last saved and load the last saved image to begin editing again.

This function can be executed by clicking File and then Revert or by pressing ALT+F and then R. A shortcut key is not assigned for this function intentionally since this will cause all changes to be lost. However, the program keeps track if changes were made to the image since last saved and if there are unsaved changes, it will prompt the user to confirm the revert operation. The file be reloaded from disk only if user clicks Yes in the dialog shown below.

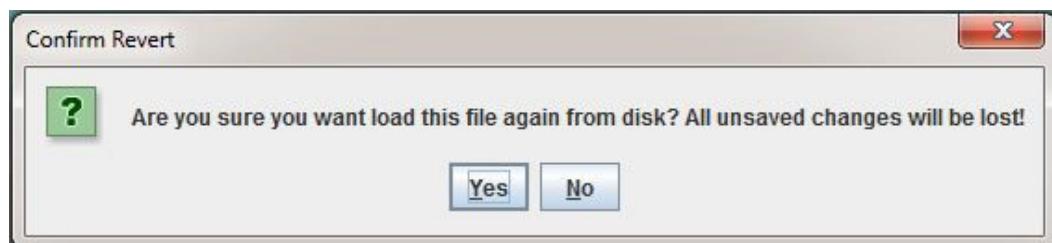
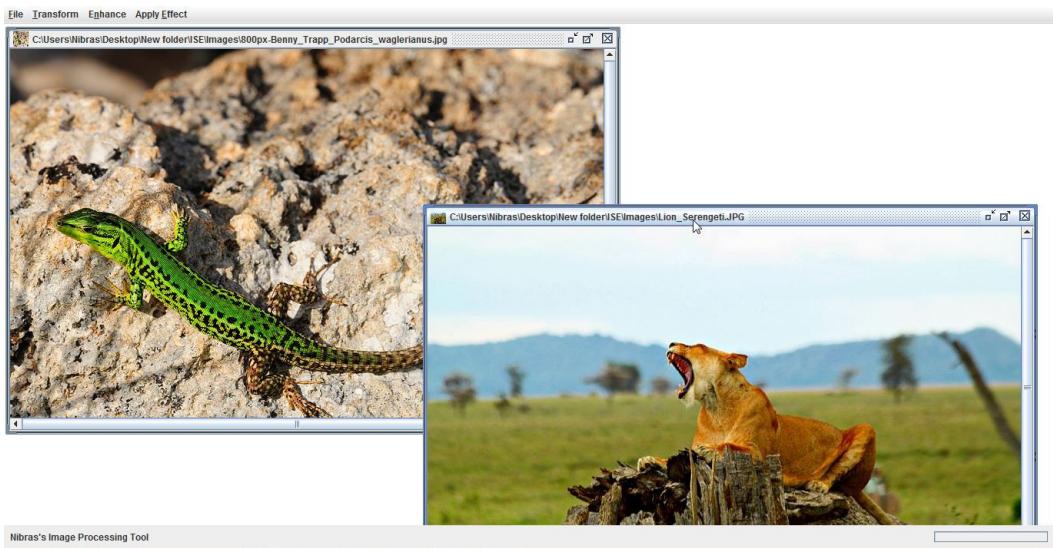


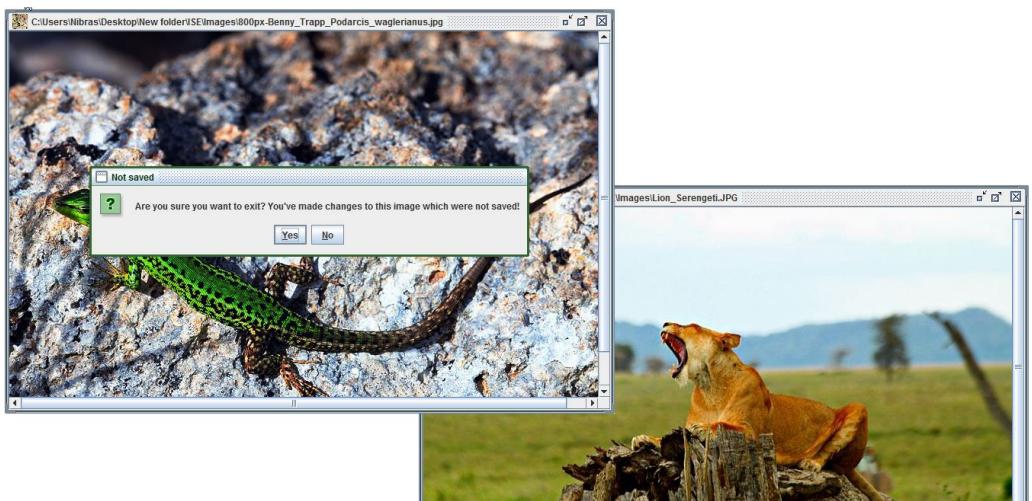
Figure 13 Prompt requesting user to confirm Revert

1.1.5 Close & Close All



**Figure 14 Illustration of Multiple Images Open Simultaneously
(*Podarcis waglerianus* (n.d.) and *A lioness roars...* (2010))**

This program allows opening multiple images simultaneously for editing. The Close command closes currently selected image(which will always be in the foreground) without closing other images or exiting the application. Close All command will close all open images without exiting the application. When one or more windows are closed, the application will show a warning and request user confirmation if the image in a window has unsaved changes.



**Figure 15: Prompt to Saves Images with Unsaved Changes
(*Podarcis waglerianus* (n.d.) and *A lioness roars...* (2010))**

Close command can be executed by clicking File and then Close or by pressing ALT+F and then C. Individual image windows can also be closed by clicking the Exit (x) icon on the top right corner of the window. Close All command can be

executed by clicking File and then Close or by pressing ALT+F and then L or by pressing ALT, SHIFT and F4 simultaneously.

1.1.6 Exit

This command can be executed by pressing ALT+F and then X or by pressing ALT and F4 simultaneously or by clicking the Exit icon on the top right corner of the application window. This will first prompt the user to confirm their intention to exit and then it will request user confirmation for each unsaved image whether to discard changes or save changes.

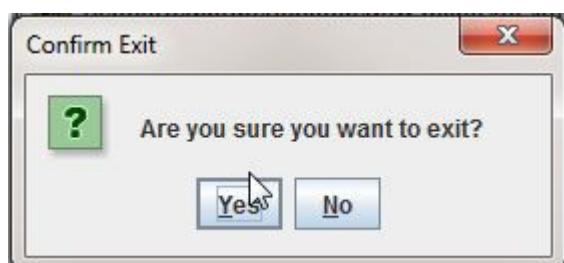


Figure 16 Prompt to Confirm Exit

1.2 Image Processing

This application possesses techniques useful for image processing divided into broad three categories.

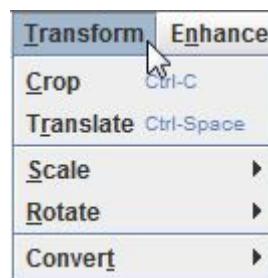
1. Transformations
2. Enhancements
3. Effects

Each of these techniques are organized in their own menu. Before the differences between these types or rather the types of techniques available in each menu could be understood, it is necessary to have a high-level idea of digital images themselves and the way they are handled and manipulated.

Every picture is made of tiny elements called pixels and each pixel has a certain numeric value denoting the intensity of a particular color(Amrasinghe n.d.). For gray-scale images, this color is White and for color images using the ARGB model, each pixel actually consists of three colors and their corresponding intensities (Amarasinghe n.d.; Đurović n.d.).

1.3 Transform

Transformations supported by this application involve techniques that in general move pixels in the original image into a new position in the processed image effectively transforming the old image into new one. Commands to convert the existing color images into gray scale or binary form is also considered a transformation and are presented in this menu. Certain techniques available in the Enhance and Apply Effects menu also support similar features however they either remove(warping) or add detail(sharpening and contrast enhancements) to existing image to create the new image. However, as a result, the original image's nature is effectively lost creating a new image. But, in transformations, the original image detail is preserved.



**Figure 17 Transform
Menu of NIMP**

The Transform menu can be accessed by either clicking Transform menu item in the menu bar or by pressing ALT+T. The commands available in the Transform menu and their explanations are given below.

1.3.1 Crop

This menu item allows you to select and cut out a portion of interest from the original image and discard unnecessary portions. For example, when capturing images using a camera, the entire area visible through the viewfinder is captured. However, this entire area may not be of interest. In such a case, Crop feature can be used.

In order to use the crop command, first, a valid image must be opened. And, then, Crop command should be executed by clicking Transform and then Crop or by pressing ALT+T and then C or by pressing CTRL and C simultaneously.

Once this command is executed, the program will show a small tip on how to use the Crop feature.

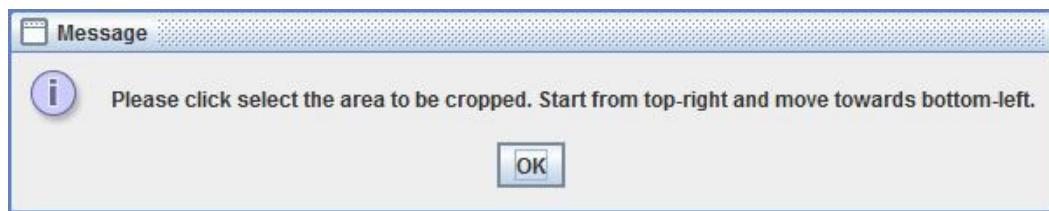


Figure 18 Tip for Using Crop

Once user clicks OK for this message, he may start selecting the portion of image to be cropped and preserved in the output image. Currently, the user can only select a rectangle and he has to start from the top-right of the area desired to be preserved. The application will guide the user with the selection by showing a pure black rectangle enclosing the currently selected area. For example, a user may wish to crop out a single orange from a picture of an orange tree. Selection and the result are shown below

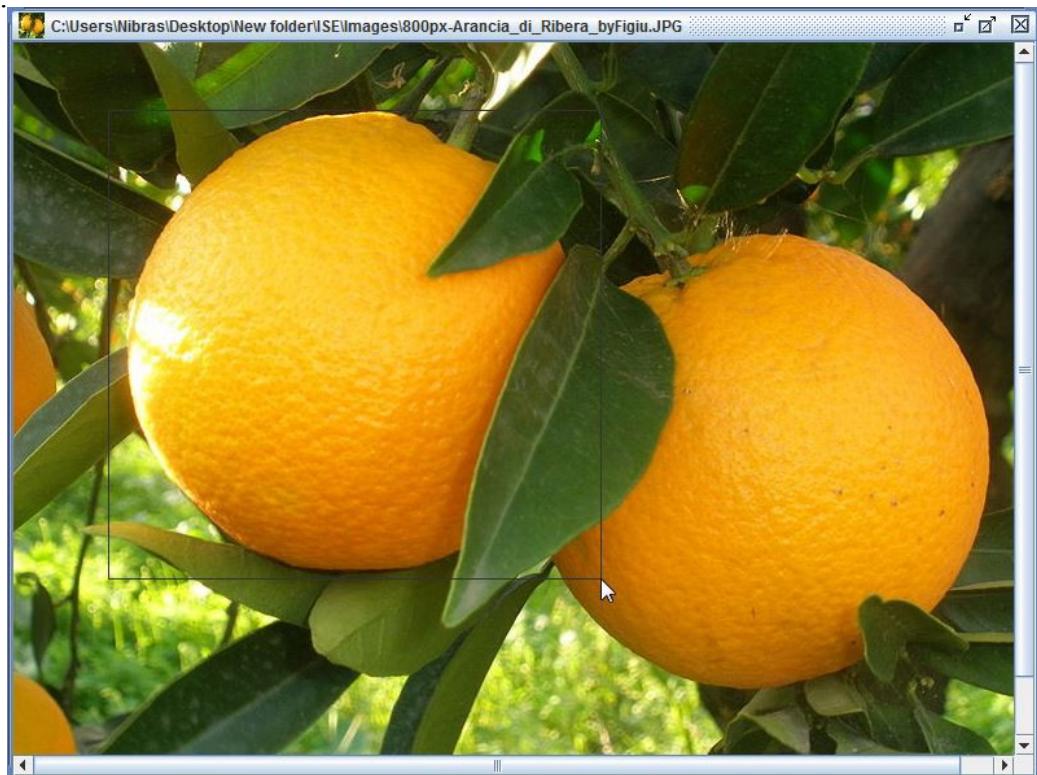


Figure 19 Image before and when Cropping
(Orange of Ribera, 2009)



CB004641

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Figure 20 Image after Cropping
(Orange of Ribera, 2009)

1.3.2 Translate

Translate allows the user to move the image vertically or horizontally or both at once while keeping the container of the image in one place (Amarasinghe 2013). This effectively allows moving a particular object in the image to a desired position. However, when image is moved, it creates space for which pixel information is not available. This will create a white area in the image.

This feature works by moving every pixel in the entire image by a set number of units vertically and horizontally.

This function can be accessed by pressing ALT+T and then r or by clicking Transform and then Translate or by pressing CTRL and SPACE simultaneously.

Executing this function will present a dialog box with two sliders which allow the user to specify the number of pixels to move in each direction. Selecting a negative value for “Vertical Displacement” would move the image upwards while selecting a negative value for “Horizontal Displacement” would move the image left side by the specified amount. If the user selects the check box called “Keep to scale”, the program will automatically synchronize both vertical and horizontal displacement ensuring they are of the same amount.

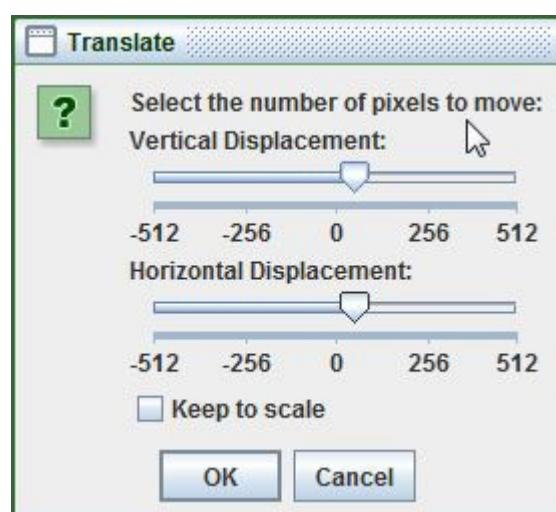


Figure 21 Prompt for Translate Parameters

Suppose the user wants to move the lion in this image to the top-right corner, after executing Translate command, user has to move both the sliders while ensuring “Keep to scale” is not selected since the image rectangular and not square and the lion is in the center.

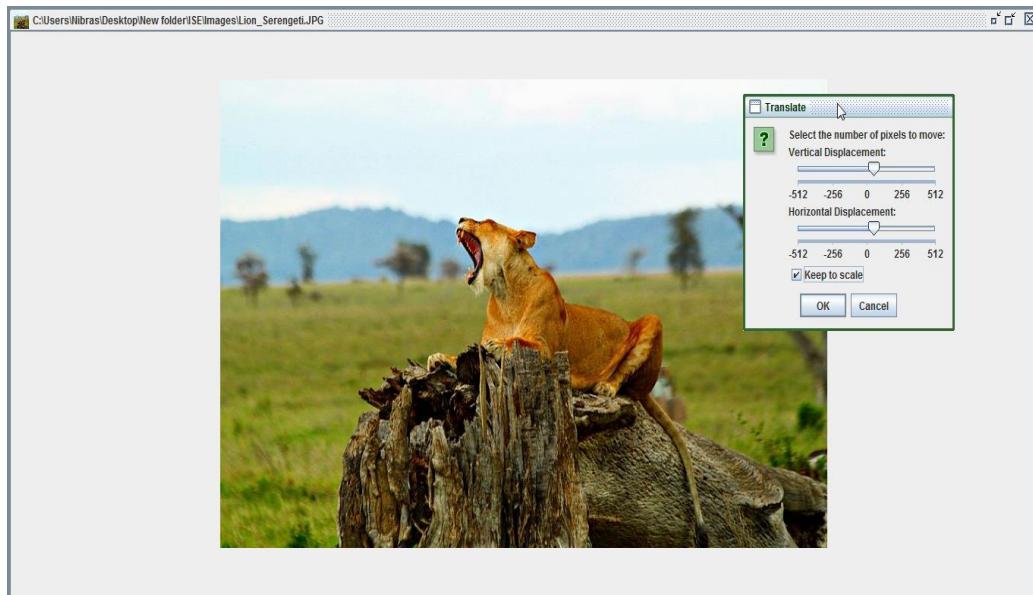


Figure 22 Image Before Translate
(A lioness roars... 2010)

This would move the lion to the top-right by the specific amount. The application supports live previews for the Translate function. Therefore, as soon as the user moves the slider, the image will be translated by the currently selected amount in the selected direction. Therefore, user does not need to blindly specify an amount and check the results. Instead, user can adjust the translation amounts as needed and once the required amount of displacement is achieved, user has to click Ok. If user clicks “Cancel” instead, the currently applied Translation technique will be removed and the image will be restored to its previous state.

This would move the lion to the top-right by the specific amount. The application supports live previews for the Translate function. Therefore, as soon as the user moves the slider, the image will be translated by the currently selected amount in the selected direction. Therefore, user does not need to blindly specify an amount and check the results. Instead, user can adjust the translation amounts as needed and once the required amount of displacement is achieved, user has to click Ok. If user clicks “Cancel” instead, the currently applied Translation technique will be removed and the image will be restored to its previous state.

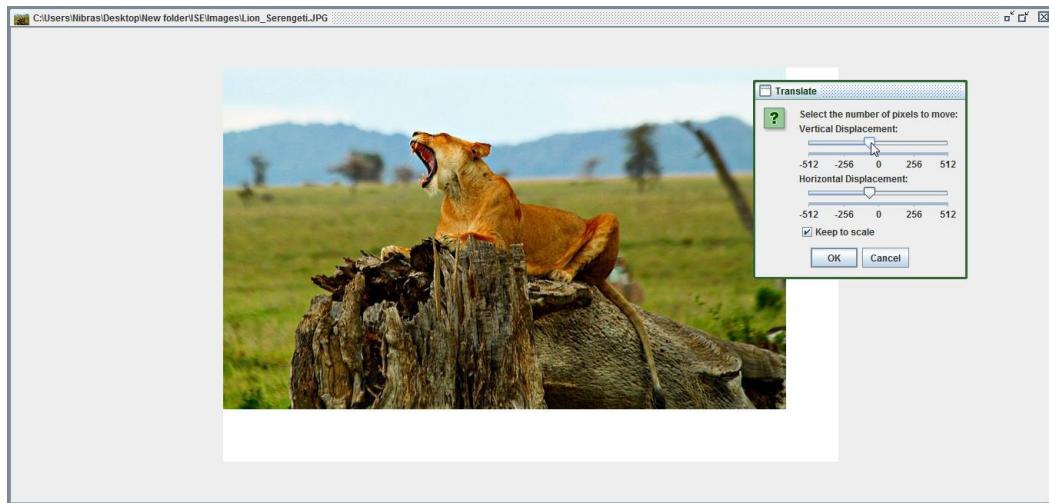


Figure 23 Image during Translation
(A lioness roars... 2010)

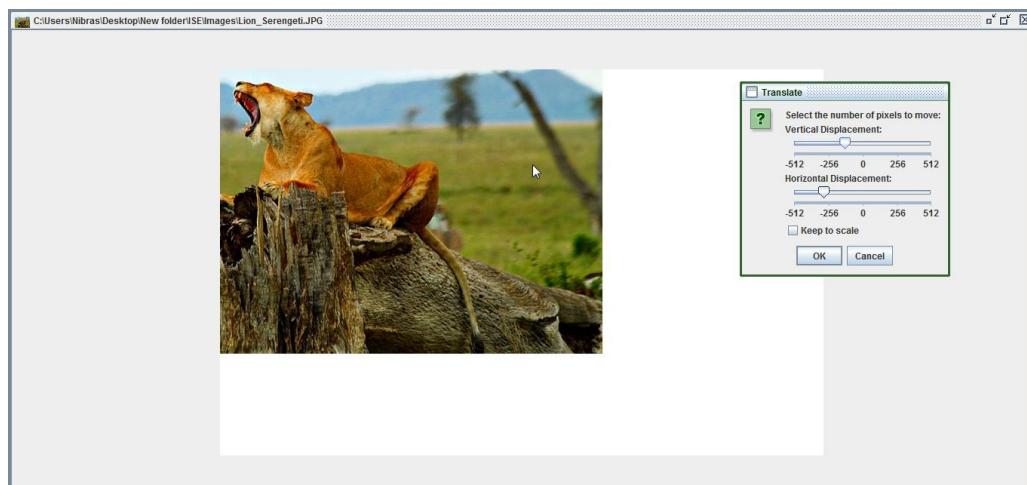


Figure 24 Image After Translate
(A lioness roars... 2010)

1.3.3 Scale

Scaling allows the user to increase the size of the image, effectively enlarging it. However, when an image's size is increased, vacant pixels are created since there is

not enough number of pixels (Amarasinghe n.d.; Đurović n.d.) or rather detail in the original image to populate a copy of the same image which is large . Hence, the application needs to use a technique to decide on the data/values to use in these vacant pixels. Based on the technique used to obtain information for the vacant pixels, this application supports two ways to scale an image.

Basic

Basic is the simpler of the two techniques supported by this application. However, it is also the fastest when executing. Basic uses the “nearest-neighbor” approximation technique to determine the value for the vacant pixels (Amarasinghe n.d.; Đurović n.d.) . In this technique, the pixel value of the pixel nearest to the vacant pixel is simply copied (Amarasinghe n.d.; Đurović n.d.) . However, since pixel values are duplicated, this may result in visible pixelation or blurring of the image and particularly when scaling to very large dimensions (Amarasinghe n.d.; Đurović n.d.).

This feature can be accessed by clicking Transform, then Scale and then Basic or by pressing ALT+T, then S and then B or by simply pressing CTRL, SHIFT and + simultaneously.

Bi-linear

Bi-linear uses a special approximation technique to average the value of the vacant pixels. This results in a smoother transition from one original pixel to the next through vacant pixels (Amarasinghe n.d.; Đurović n.d.). Although this method is capable of producing a result of higher quality, it may suffer from performance constraints.

In bi-linear method, the distance between two pixels obtained from the original image are considered to be one unit and the fractional distance between the vacant pixel and each of original pixels used to calculate the value for vacant pixel using a weighted average (Amarasinghe n.d.; Đurović n.d.). This is best illustrated using a diagram.

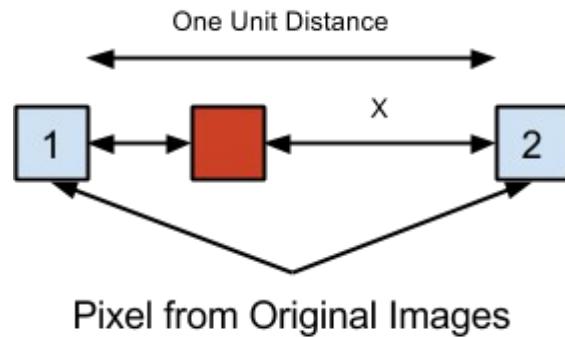
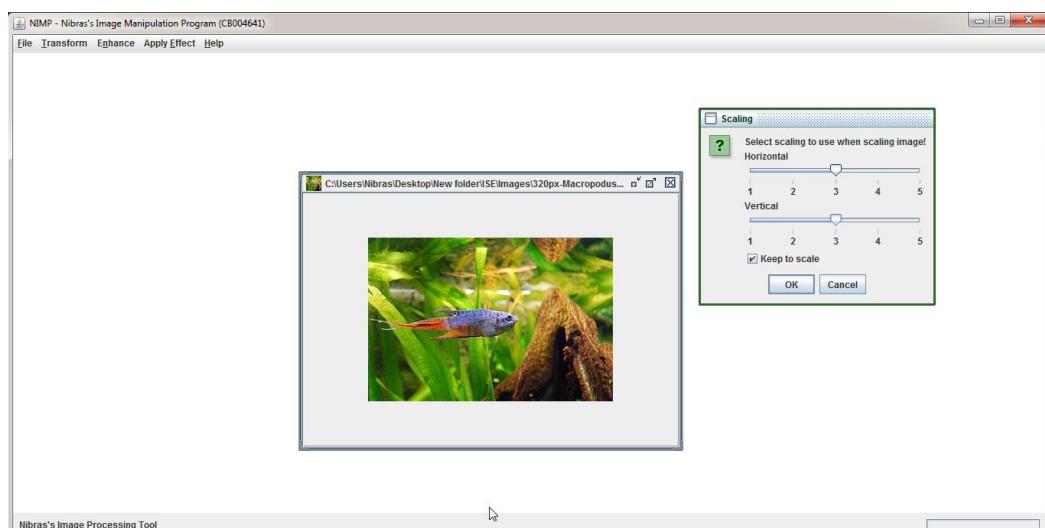


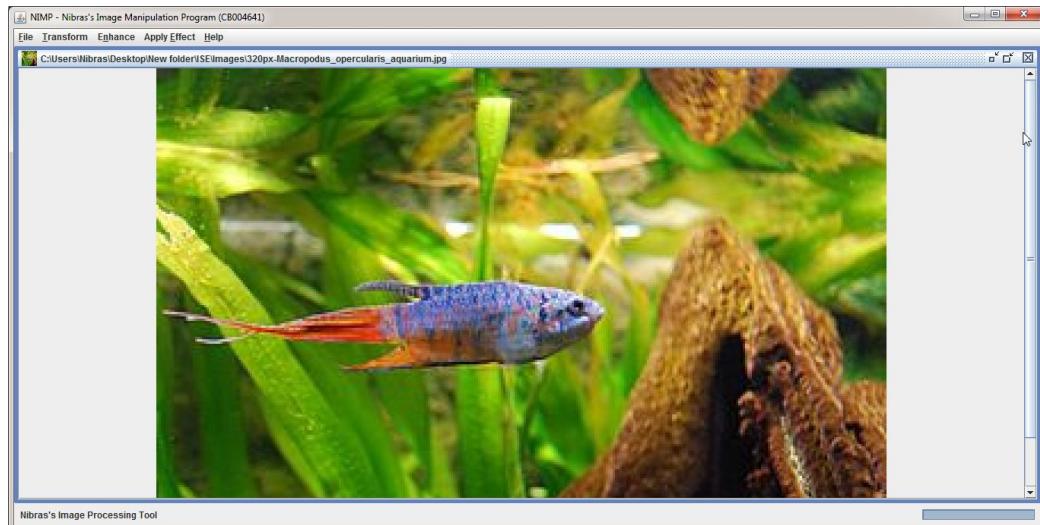
Figure 25 Illustration of Bi-linear Interpolation

This feature can be accessed by clicking Transform, then Scale and then Bilinear or by pressing ALT+T, then S and then L or by simply pressing CTRL, ALT, SHIFT and + simultaneously.

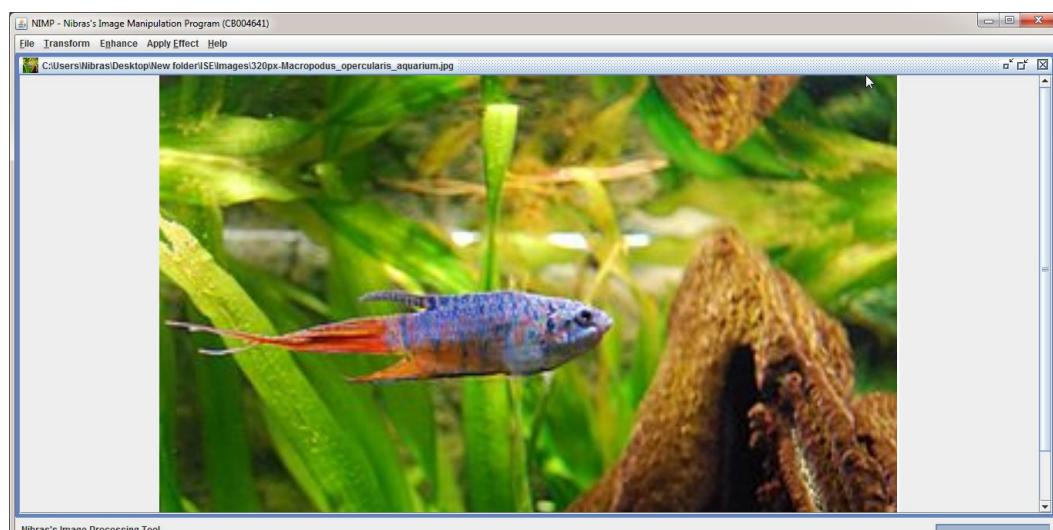
Once Scale command is executed using Basic or Bi-linear technique, a dialog will be displayed requesting the user to enter the factor by which to scale the image in each direction (vertical and horizontal). User may click the “Keep to scale” check-box to ensure that both vertical and horizontal scaling factors are exactly equal.



**Figure 26: Image before Scaling and Prompt for Scaling
(Paradiesfisch 2008)**



**Figure 27 Image After Basic Scaling
(Paradiesfisch 2008)**



**Figure 28 Image After Bi-linear Scaling
(Paradiesfisch 2008)**

1.3.4 Rotate

Sometimes when images are captured, there is a possibility that the object of interest may not be in the desired orientation. In such cases and whenever it may be desired to rotate an image, similar to rotating a physical photograph, this feature may be

used. This can be used to alter the orientation of an image for further processing or viewing.

This command uses the standard matrix rotation formula (WolframMathWorld 2014; Amarasinghe n.d.; Đurović n.d.) and assumes the center of the image as origin.

$$x' = x \cos a - y \sin a$$

$$y' = x \sin a + y \cos a$$

where a denotes the angle by which the image is to be rotated.

This application uses this formula to map the pixels in the original image to their corresponding location in the desired output image.

Similar to Scale, Rotate also can result in vacant pixels and thus, rotation can also be done using Basic or Bi-linear techniques (see Scale for information of Basic and Bi-linear approximation technique).

In order to rotate an image using Basic technique, the user has to first click Transform, then select Rotate and finally click Basic. Alternatively, user may access rotation using basic by pressing CTRL, SHIFT and R simultaneously. Another way to execute this command is to press ALT+T, then, R and then B.

In order to rotate an image using bi-linear technique, the user has to first click Transform, then select Rotate and finally click Bi-linear. Alternatively, user may access rotation using bi-linear by pressing CTRL, ALT, SHIFT and R simultaneously. Another way to execute this command is to press ALT, T, then, R and then L.

Once this feature is executed, the application will prompt the user to select an angle for rotation. User may select a negative angle to rotate the image clockwise and a positive angle to rotate the image anti-clockwise.

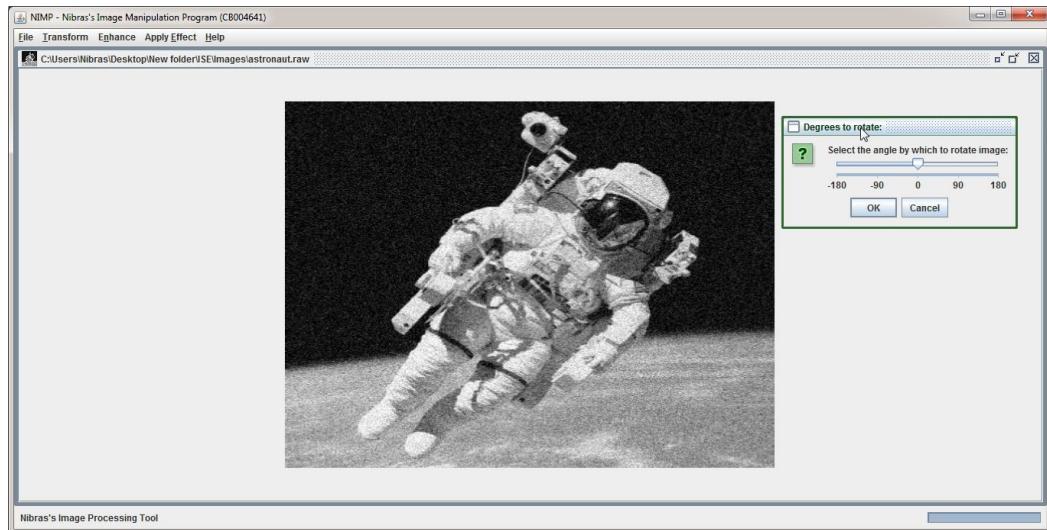


Figure 29: Image before Rotation and Prompt for Rotation

Since the image of the astronaut is tilted, a user may wish to position the astronaut vertically and view the image. By visual inspection, the stature of the astronaut appears to be tilted about 45 degrees clockwise. Therefore, the image needs to be rotated 45 degrees anti-clockwise to place the astronaut straight relative to the frame. Similar to Translate, Rotate also supports live previews which updates and rotates the image as the user moves the slider using the currently select value. Once the user has rotated to a desired angle, the user may click Ok. If user clicks Cancel, all changes made during the last rotate operation will be discard and the image will be restored to its previous state.

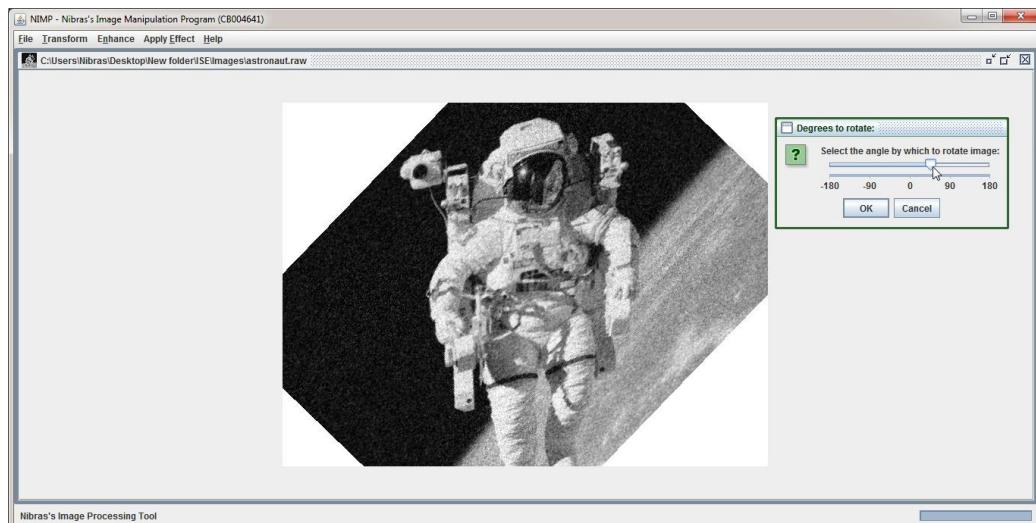


Figure 30 Image After Rotation

1.3.5 Convert

For aesthetic reasons or to enhance visibility of features which may not be visible in color images, a user may wish to convert an image into a pure black & white (binary) image or a gray-scale image.

Each pixel in a color image has a particular amount of red, green and blue colors.

Each pixel can be considered to consist of three sub-pixels with each corresponding to a particular primary color. (Amarasinghe n.d.; Đurović n.d.)

The following image is converted to black and white and gray-scale.



**Figure 31: Image before Conversion
(A variety of corals... 2010)**

1.3.6 Convert - Black & White

This command may be accessed by clicking Transform, Convert and then Black & White or by pressing ALT+T then T and then B or by pressing CTRL and B simultaneously. This first converts the color image to gray-scale using the averaging technique and then assumes any pixel with less than 50% black(128 pixel value) to be white and anything above to be black. This results in an image with only black

and white and colors with no shades of gray. Since this image has only two colors, it's also called a binary image (Amarasinghe n.d.).

Once the sample image is converted to black and white, it produces an output which shows all ground features in black and displays the water as white.



**Figure 32: Image after Conversion to pure Black & White
(A variety of corals... 2010)**

1.3.7 Convert - Gray Scale

When the intensities of all three colors are zero, it results in black and when intensities of all three colors are at their maximum value of 255, it produces white (Amarasinghe n.d.; Đurović n.d.). Similarly, when the intensities of all three colors are equal and between 0 and 255, it results in a shade of gray with an intensity between 0 (being black) and 255 (being white) is produced. This application uses this technicality to both store and manipulate gray scale images. In essence, every gray scale image is a color image with equal intensities of red, green and blue with regard to this application.

When a color image is to be converted to a gray-scale image, a specific technique must be utilized to determine the corresponding shade of gray for a particular mix of

red, green and blue. There are three major techniques used to achieve this and each is more suited for certain types of images (Cook 2009; Entropymine.com n.d.; the GIMP documentation 2014). However, in most cases, the difference is minute or nil. This application supports two of the three such techniques.

Convert - Gray Scale - Averaging

In this technique, the application adds the values of all three colors and divides by three (Cook 2009; Entropymine.com n.d.) to calculate the average and assigns it as the intensity for each color element.

This feature can be accessed by clicked Transform, Convert, Gray-scale and then Averaging or by press ALT+T, then T, then G, then A or by pressing CTRL and G simultaneously.

The result of this operation for the selected sample image is shown below.



**Figure 33: Image converted to Gray-scale using Averaging
(A variety of corals... 2010)**

Convert - Gray Scale - Luminescence

Although in the computerized representation of images, red, green and blue are simply considered different components of an image, each with an intensity of 0 to 255, it is not how it is perceived by the human eye (Cook 2009; Entropymine.com n.d.). Human eye perceives Green as a more intense color than Red and Blue and perceives Red as more intense than Blue (Cook 2009; Entropymine.com n.d.). Taking this into consideration, another technique is devised which assigns a weight to each of the colors when averaging resulting in an image which is more accurate as per human perception (Cook 2009; Entropymine.com n.d.). This technique is called Luminescence preserving technique (Cook 2009; Entropymine.com n.d.).

This feature can be accessed by clicked Transform, Convert, Gray-scale and then Luminescence or by press ALT+T, then T, then G, then L.



**Figure 34: Image converted to Gray-scale using Luminescence Preservation
(A variety of corals... 2010)**

1.4 Enhance

This menu item possesses techniques useful for highlighting details invisible in the original image. These techniques enhance the image to improve visibility of minute details. Unlike techniques in Transform, enhancement features try to preserve the original image in its entirety. Additionally, all the features currently available in this

menu manipulate the values of each individual pixel without modifying their location. This menu can be accessed by clicking Enhance from the menu bar or by pressing ALT, N.

1.5 Noise Reduction

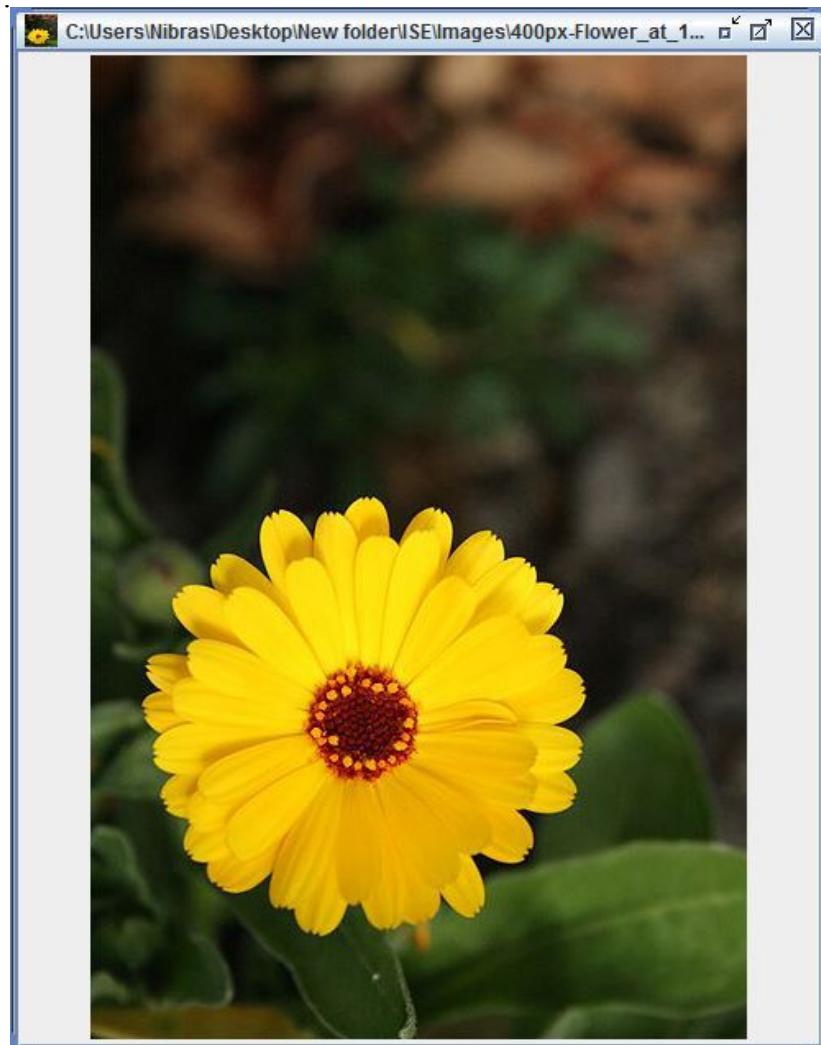
Images are subjected to different types of noises and before noise reduction techniques can be discussed, the different types of noises must be understood. All noise reduction techniques are made available under the menu item called “Smoothen” which is a menu item in “Enhance”.

There are many different types of noises (Jain and Kasturi et al, 1995, pp. 112-40; Amarasinghe n.d.) but this application supports removing only two distinct types of noises. The two different types of noises this application is capable of removing are explained below.

Gaussian Noise

In nature, from heights of people to sizes of a leaves of a tree vary. However, this variation can be modeled and explained using a model called Normal Distribution (MATHSisFUN n.d.; Weisstein n.d.; Narasimhan 1996). Normal distribution is a bell shaped graph which shows the frequency of different possible sizes/intensities of ‘things’ that occur in nature (MATHSisFUN n.d.; Weisstein n.d.; Narasimhan 1996). Similarly, when images are digitized, these the signals obtained from the image sensor are subject interference from circuits and other sources(Jain and Kasturi et al, 1995, pp. 112-40; MATHSisFUN n.d.; Weisstein n.d.; Narasimhan 1996). These interferences also can be modeled using the normal distribution model. Normal distribution is also called Gaussian Distribution(MATHSisFUN n.d.; Weisstein n.d.; Narasimhan 1996). These interferences that follow the Normal Distribution result in noise in the image which is called Gaussian Noise(MATHSisFUN n.d.; Weisstein n.d.; Narasimhan 1996). Since these noise follow a certain Mathematical model, they can be reversed by applying an algorithm which tries to remove this natural variation.

The following is a sample image with Gaussian Noise.



**Figure 35: Sample Image with Gaussian Noise before Enhancing
(Photograph of a flower... 2007)**

Salt and Pepper Noise

Salt and pepper noise is a grainy type of noise that can occur in images. However, they are characteristic in that, unlike Gaussian noise which can be of any color, salt and pepper noise are either white (salt) or black(pepper) colored dots/pixels that occur randomly in images (Jain and Kasturi et al, 1995, pp. 112-40; Amarasinghe n.d.).

Following Image shows a sample of salt and pepper noise.

1.5.1 Enhance - Smoothen - Weighted

When applying a weighted filter, for each pixel eight of the pixels around it and the particular pixel itself is added together (often after multiplying an integer called the weight) and then averaged by dividing with the sum of all these weights (Amarasinghe n.d.). There are multiple types of weighted averaging filters and each of these can be accessed by clicking Enhance, Smoothen, Weighted and then their particular names. They also be accessed using the keyboard shortcut by pressing, ALT+N, then M and then W and then A for Averaging, K for K-Value, G for Gaussian 1 or 2 for Gaussian 2 techniques.

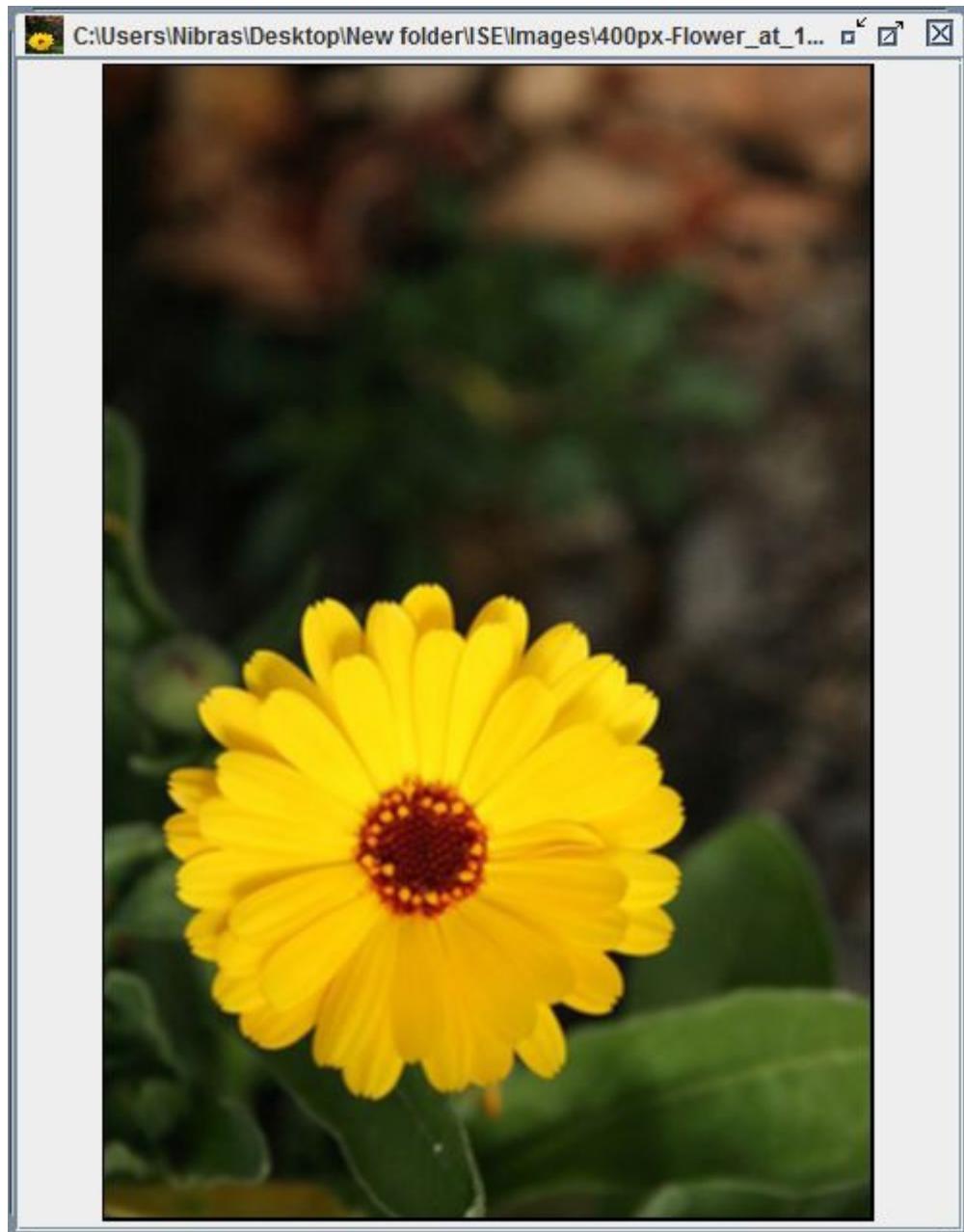
These filters are useful for eliminating Gaussian Noise (Jain and Kasturi et al, 1995; Amarasinghe n.d.).

Averaging and K-Value.

In these techniques, the weight used to multiply each pixel is 1. When using Averaging, only the pixel immediately next to the image is considered or rather a

square of 9 pixels at a time. K-Value considers K numbers of pixels at a time or rather a square of K+1 by K+1 (Amarasinghe n.d.).

Following shows an output of these filters applied to the sample image. (K=5 for K-value filter)



**Figure 36: Image after Averaging
(Photograph of a flower... 2007)**

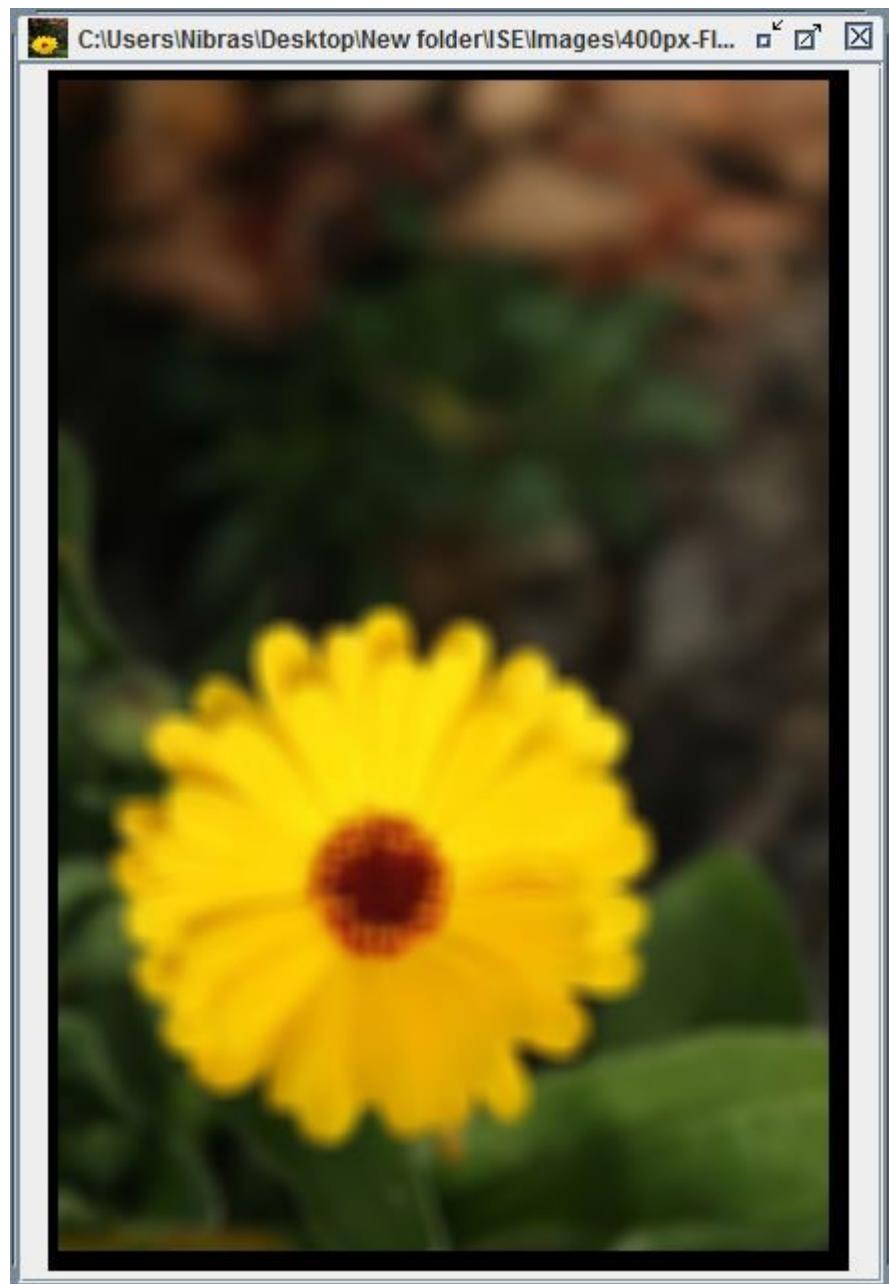


Figure 37: Image after K-Value
(Photograph of a flower... 2007)

Gaussian 1 & Gaussian 2.

These filters consider only a square of 9 pixels at a time. However, they apply a different set of weights based on reverse modeling the Gaussian distribution (Jain and Kasturi et al, 1995, pp. 112-40; Amarasinghe n.d.)..

Following shows output of these techniques applied to sample image.

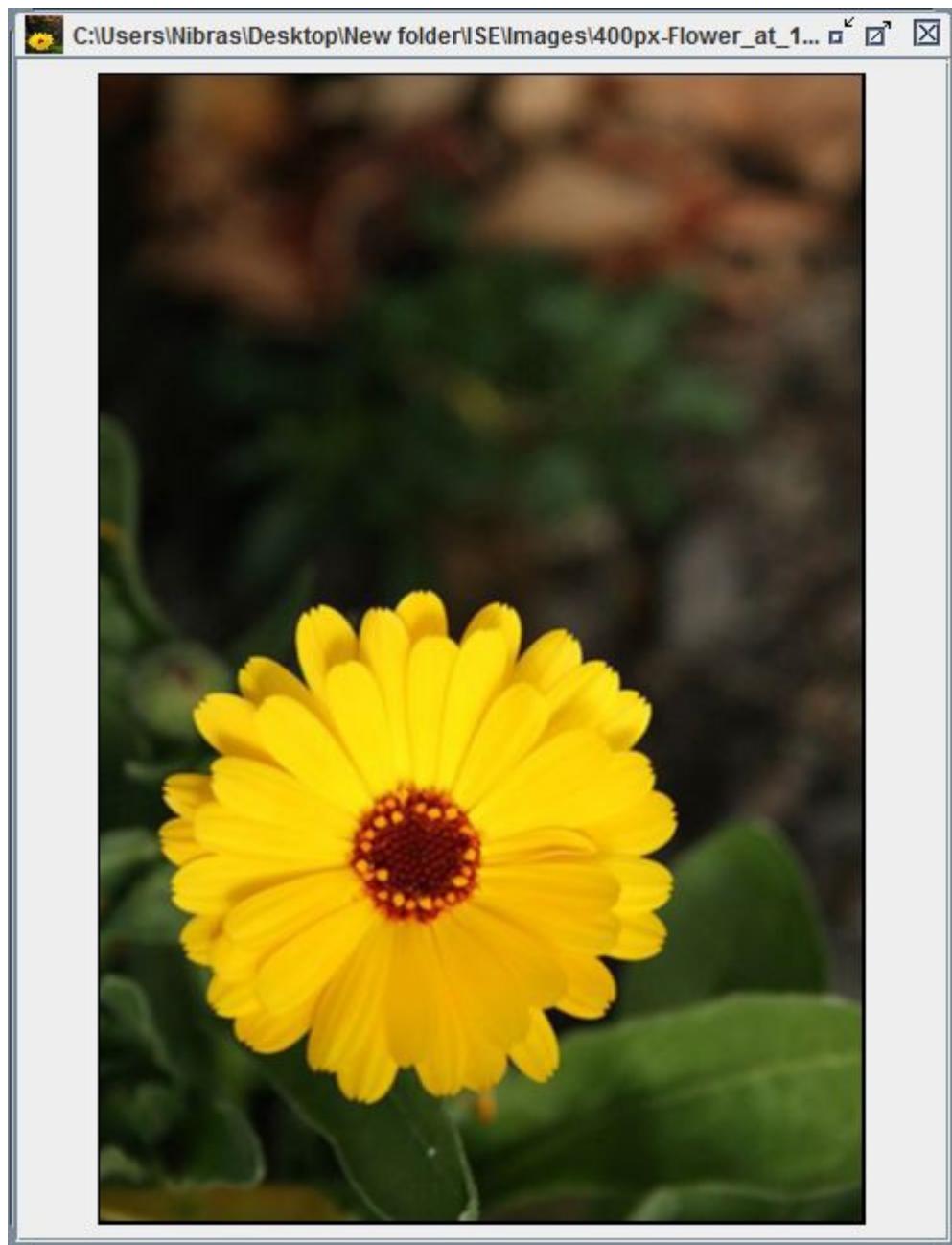
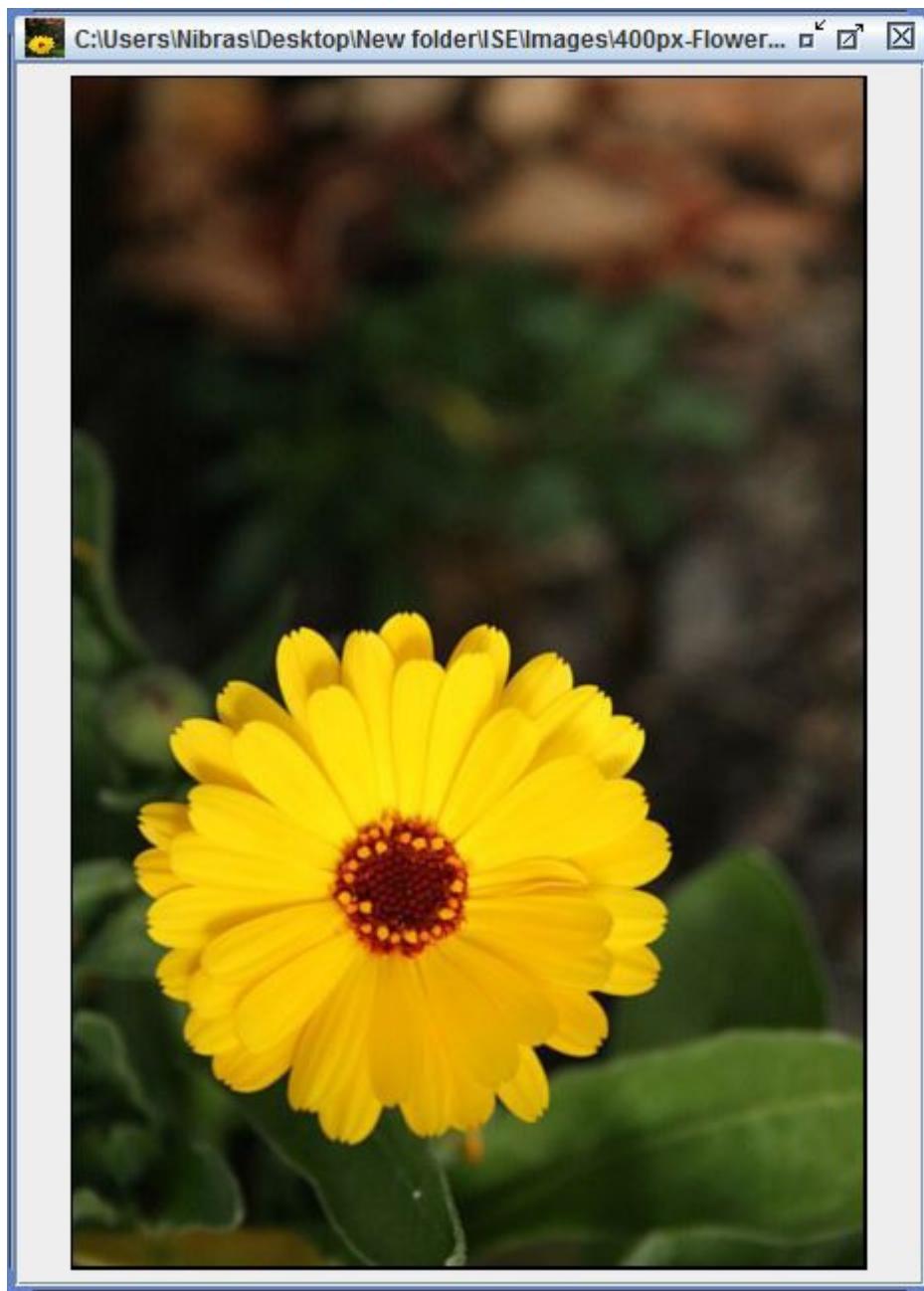


Figure 38: Image after Gaussian Filter 1
(Photograph of a flower... 2007)



**Figure 39: Image after Gaussian Filter 2
(Photograph of a flower... 2007)**

1.5.2 Enhance - Smoother - Median

There are multiple types of median filters and each of these can be accessed by clicking Enhance, Smoothen, Median and then their particular names. They also can be accessed using the keyboard shortcut by pressing, ALT, N, then M and then M and then M for Median, N for Min and X for Max. Similar to weighted average filters, these techniques also consider a square of 9 pixels at a time (Amarasinghe n.d.). However, they create a local list of color intensities of the 9 pixels, sort it and replace the center pixel of the square with the Median (number in the middle of the

sorted list, Max (highest number in the sorted list) or Min (lowest number in the sorted list) (Amarasinghe n.d.).

These filters are useful for removing salt and pepper noise.

Following shows these filters applied to the sample image.



Figure 40: Sample Image after Median Mid filter

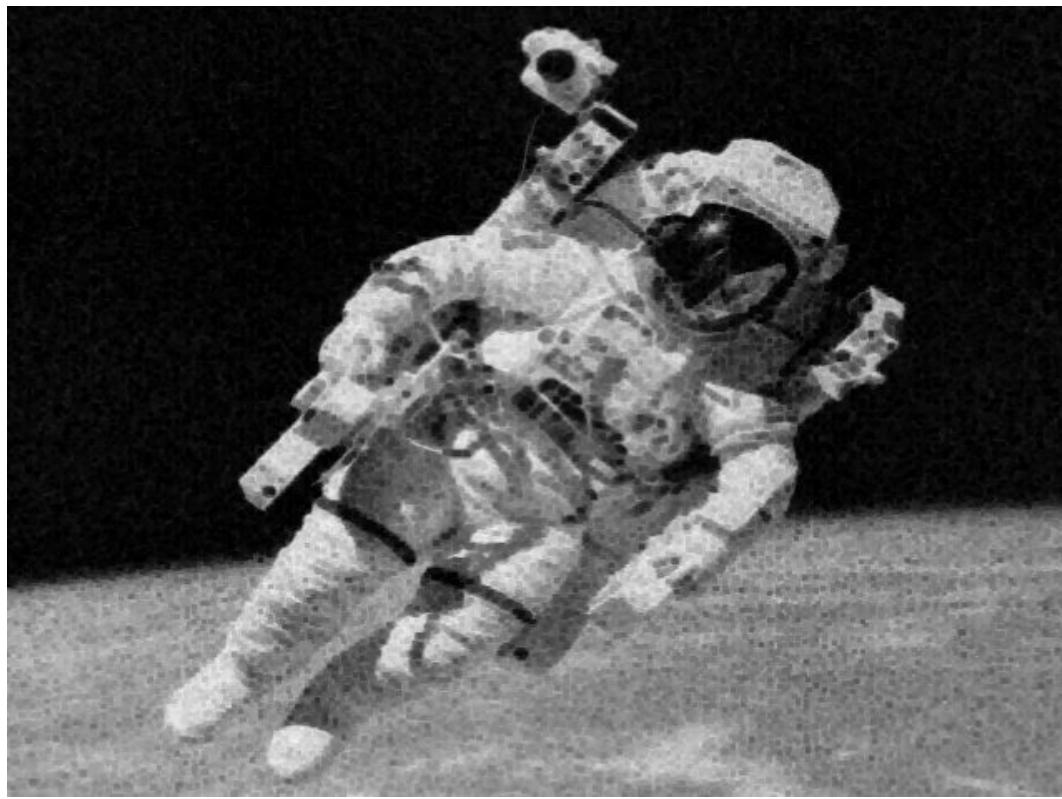


Figure 41: Sample Image after Median Max filter

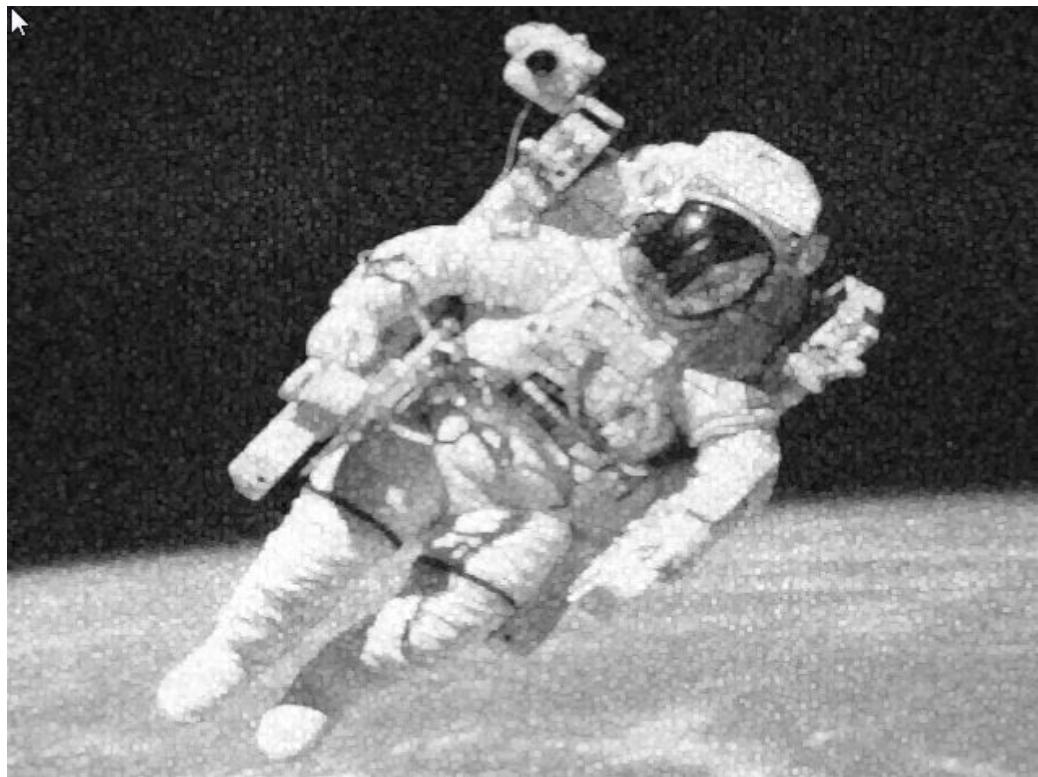


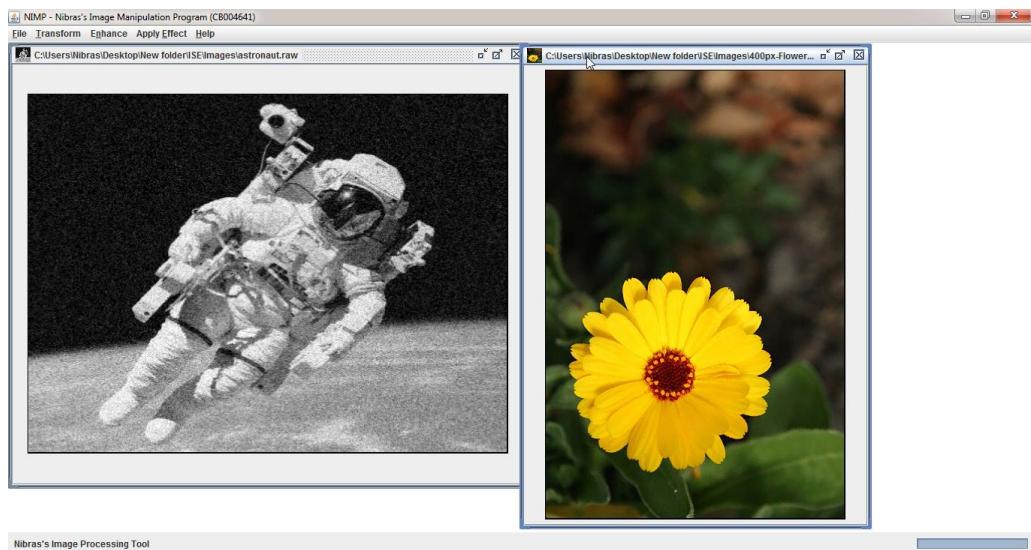
Figure 42: Sample Image after Median Low filter

1.5.3 Enhance - Smoother - Mode

This filter can be accessed by clicking Enhance, Smoothen and then Mode or by pressing ALT, N, then M and then O. This technique also considers a square of 9

pixels at a time. It creates a local frequency distribution of the value and replace the pixel in the middle with the pixel that occurs the most in the distribution (mode) (Amarasinghe n.d.). This technique can be used in removing both, Gaussian as well as salt and pepper types of noises.

Following shows this filter applied to each of the sample images.



**Figure 43: Samples Images after Mode filter
(Photograph of a flower... 2007)**

1.5.4 Enhance - Sharpen

When images are captured or processed, sometimes blurring occurs which may distort details (Jain and Kasturi et al, 1995, pp. 112-40). This especially causes the edges to fade and not represent the actual edges as it may have been presented in the original scenery that was captured. In such cases, sharpening techniques can be applied to sharpen or rather highlight the edges and free them of blurs or distortions.

There are multiple techniques used to sharpening. However, some of these techniques also create artifacts or lines on the smoother areas of the image as well (Jain and Kasturi et al, 1995, pp. 112-40). Therefore, a filter based approach which detects the edges is used to sharpen images in this application (Jain and Kasturi et al, 1995, pp. 112-40).

At first, the application considers each pixel individually and then selects a square of pixel around the particular pixel. Then, it multiplies each of the pixels in this square with values from a set of predetermined values. This results in an output value for each of the pixels in the image which can referred to as mask. Due to the nature of the values used to multiply, this mask contains significantly different values for edges and a somewhat equally distributed set of values for smoother areas. Then, this mask is combined with the original image to create the sharpened output image. Based on the set of values (called a filter) used for creating the mask, there are multiple sharpening techniques supported by this application (adapted from Amarasinghe n.d.).

Each of these sharpening techniques can be accessed by clicking Enhance, Sharpen and then the desired technique or by pressing ALT, N, and then H and then U for Unsharp Masking, S for Sobel, L then D for Laplacean Dark or L and then L for Laplacean Light. Following is an image with distorted edges



**Figure 44: Sample Image used for Sharpening
(Joshua Tree, 2013)**

Following sections describe above techniques.

Unsharp Masking

This technique first blurs the image and then uses the difference between the blurred image and the original image to find areas that require sharpening. Then, adds the difference to actually sharpen the image (Amarasinghe n.d.).



Figure 45: Sharpened Version of Sample Image (Unsharp Masking)
(Joshua Tree, 2013)

Sobel

This is an extremely sensitive edge detection filter. This can produce visible artifacts in the image.

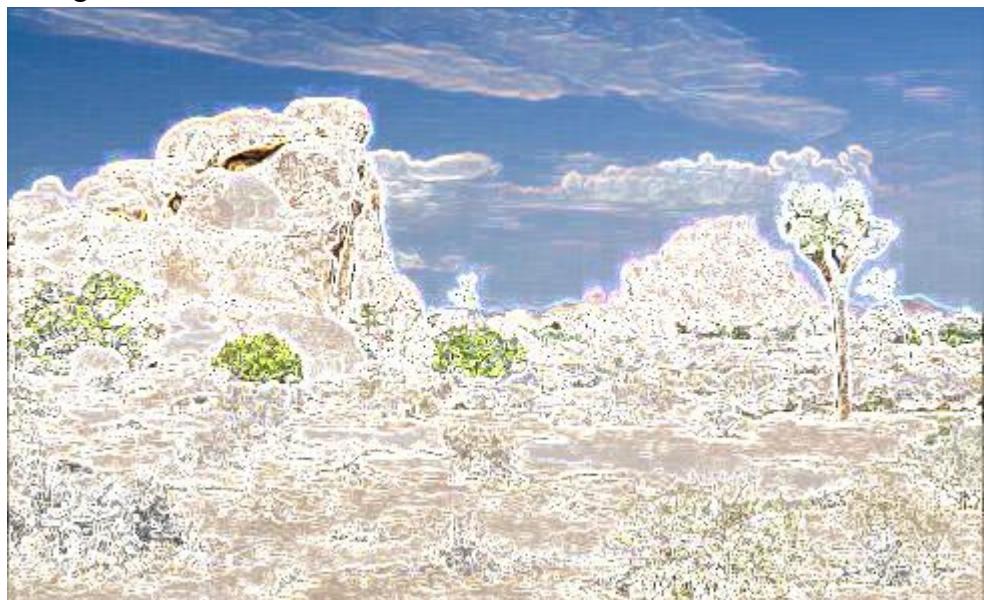


Figure 46: Sharpened Version of Sample Image (Sobel)
(Joshua Tree, 2013)

Laplacean Dark and Light

Both these use a filter to detect edges and combine it with the image to sharpen it (Amarasinghe n.d.). The Dark version darkens the edges while the Light version lightens the edges when detecting edges.



Figure 47: Sharpened Version of Sample Image (Laplacean Dark)
(Joshua Tree, 2013)

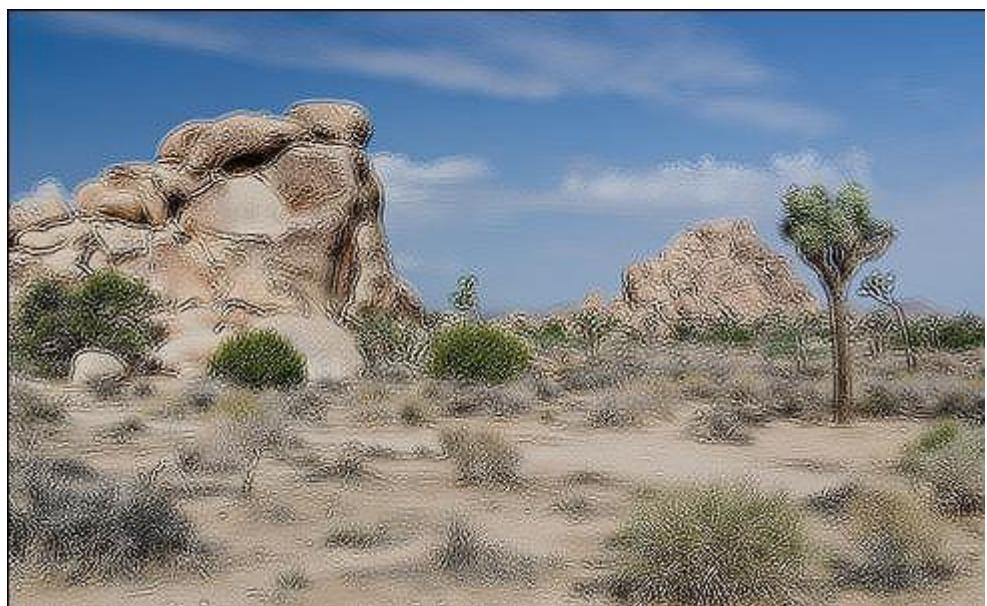


Figure 48: Sharpened Version of Sample Image (Laplacean Light)
(Joshua Tree, 2013)

1.5.5 Enhance - Adjust Brightness

This features by either reducing or increasing the intensity of colors at each pixel (Amarasinghe n.d.). This allows the user to either lighten a dark picture or to darken a whitish picture.

This feature can be accessed by clicking Enhance and then clicking Adjust Brightness or by pressing ALT, N and then B. Once executes this command, the program will prompt the user to select an amount by which to adjust brightness.

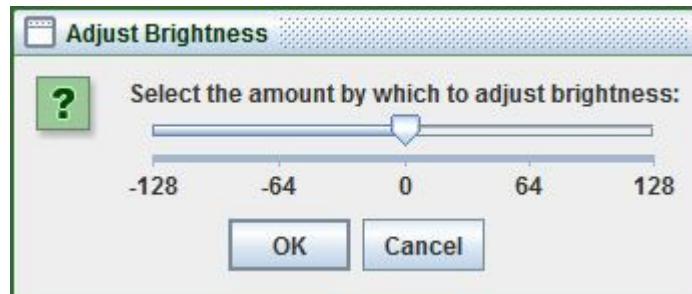


Figure 49: Prompt to Adjust Brightness

Selecting a negative value will darken the image while selecting a positive value will lighten the image. This application supports live previews for brightness adjusts and will immediately apply the currently selected adjustment to the image. User has to click Ok once the desired level is reached. If user clicks Cancel, image will be restored to the state before this command was selected.

For example, following image looks really dark. It can be enhanced by increasing brightness.

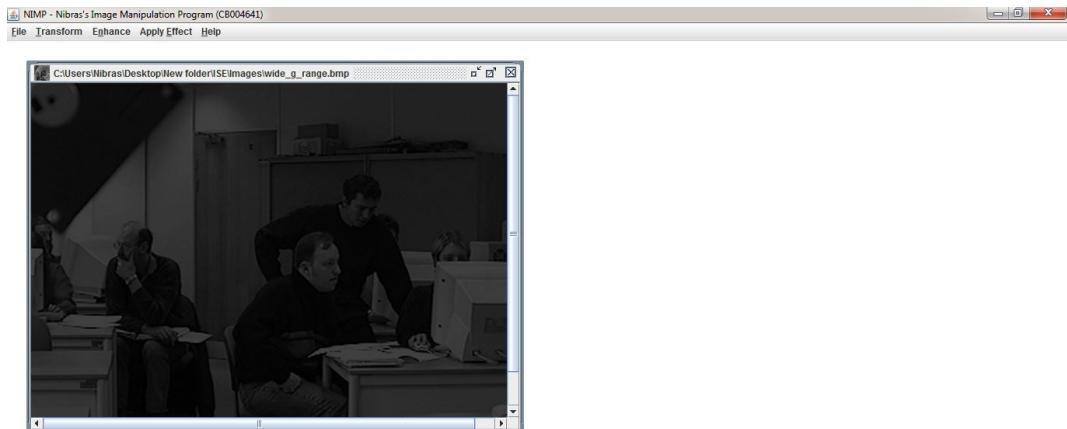


Figure 50: Image before Brightness Adjust

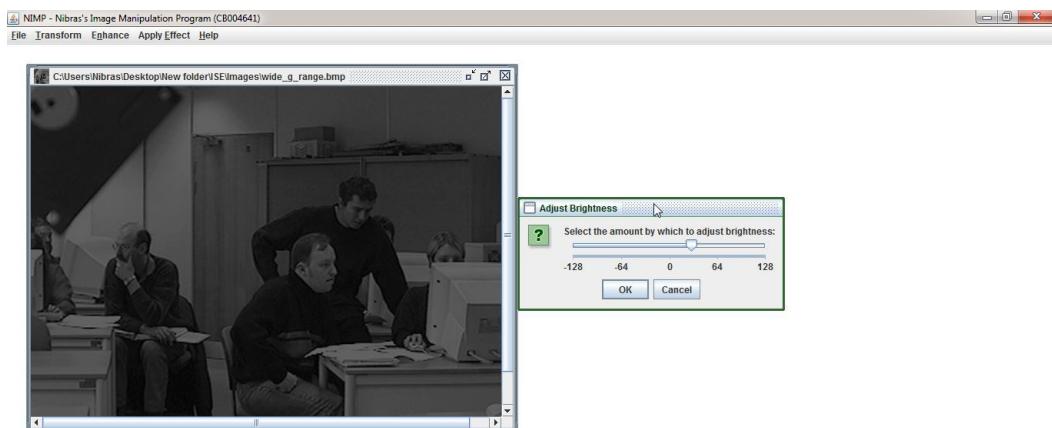


Figure 51: Image during and after Brightness Adjust

1.5.6 Enhance - Adjust Contrast

When images are captured using a sensor, the intensities of colors are reduced and capped into a certain range to avoid saturation of images (Jain and Kasturi et al,

1995, pp. 112-40). Saturation refers to the fact that when the capturing occurs, the sensors finds the intensity as too high and records it as maximum intensity (Jain and Kasturi et al, 1995, pp. 112-40). However, this correction leads to reduced representation of color variation in images. In order to do this, contrast enhancement is used (Jain and Kasturi et al, 1995, pp. 112-40).

For an image, a graph showing the frequency of a color at each intensity can be constructed (Amarasinghe n.d.; Đurović n.d.). This is called a histogram . In the histogram of an image with low color variation, intensities tend to cluster around a particular value (Amarasinghe n.d.; Đurović n.d.). Contrast enhancement techniques attempt to increase this variation to create an enhanced image(Amarasinghe n.d.; Đurović n.d.).

This application supports three different techniques for histogram equalization. Each of these techniques can be accessed by clicking Enhance, Adjust Contrast and then selecting the desired technique. Alternatively, they can be accessed by press ALT, N, then C and then N for Naive enhancement, H and then E for Histogram Equalization, H and then S for Histogram stretch to a 0 -255 range or H and then C for for Histogram Stretch to a particular range.

The following image given for the special task seems washed with more colors clustered towards whiter region.



Figure 52: Image with Low Contrast before Enhancement

Naive contrast enhancement technique allows the user to specify a scale by which to multiply the color intensities to better distribute colors (Amarasinghe n.d.; Đurović n.d.). Once user executes this command, the program will prompt the user to specify the scale and it will adjust the contrast the image as the user selects a value allowing the user select a desired level. The user can click Ok once the desired level is reached. Clicking cancel will restore the image to the state before this command was executed.

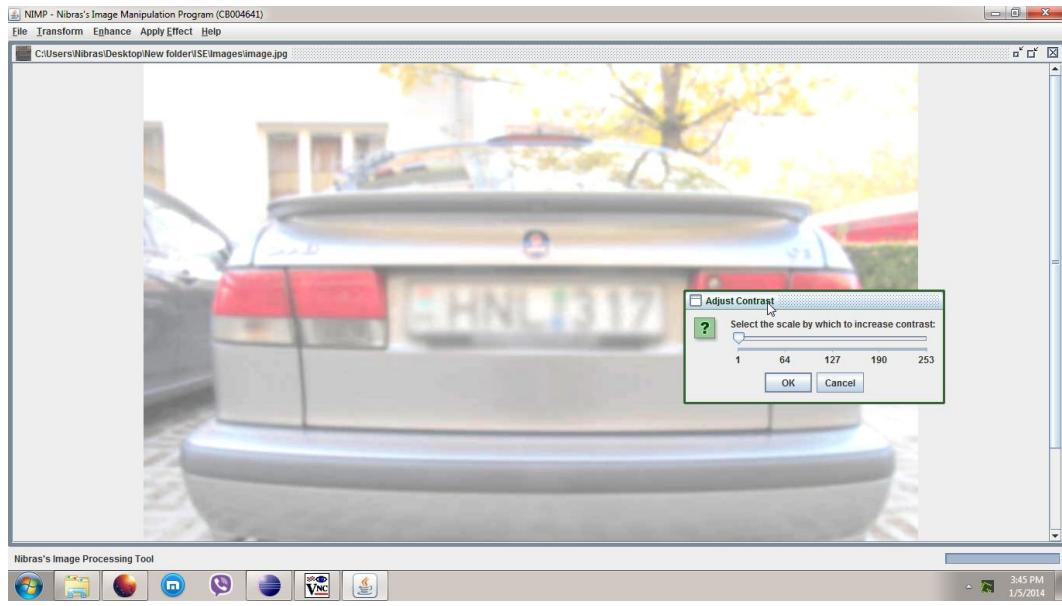


Figure 53: Prompt for Naive Contrast Enhancement and Result after Application

Histogram stretch allows the user to spread the current frequencies to a more wider ranges by assigning the frequency of a particular to a more intense or less intense color (Amarasinghe n.d.; Đurović n.d.). When user executes Histogram Stretch (Custom), the application will prompt the user to select the maximum and minimum intensities to user in the target image. Selecting the Equivalent check box will ensure that the maximum value is always the difference between the maximum possible and selected minimum value or vice versa. When user selects Histogram Stretch (0-255), the program executes the same command with 0 as minimum and 255 as maximum.

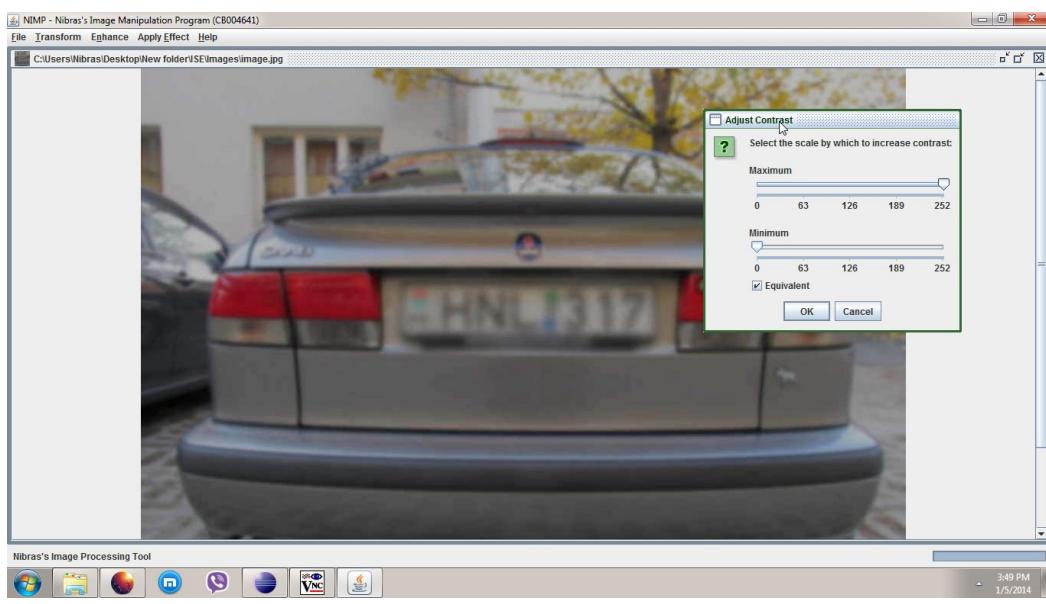


Figure 54: Prompt for Histogram stretch and Result after Application

Histogram Equalization is a more advanced technique which attempts to spread the intensities by not only reassigning frequencies but also by adjusting the level of frequency at each level (Amarasinghe n.d.; Đurović n.d.).

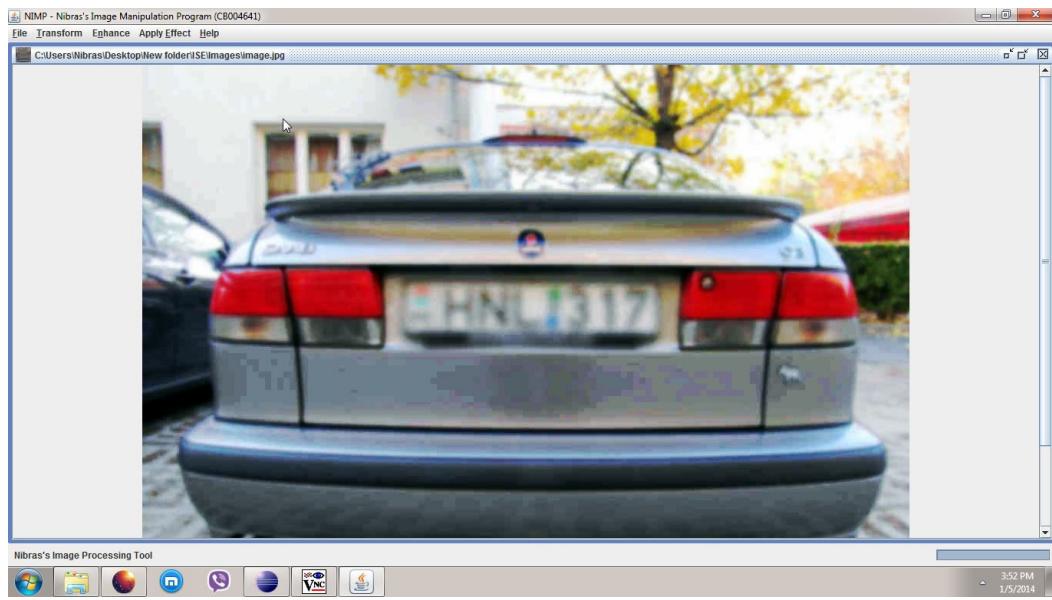
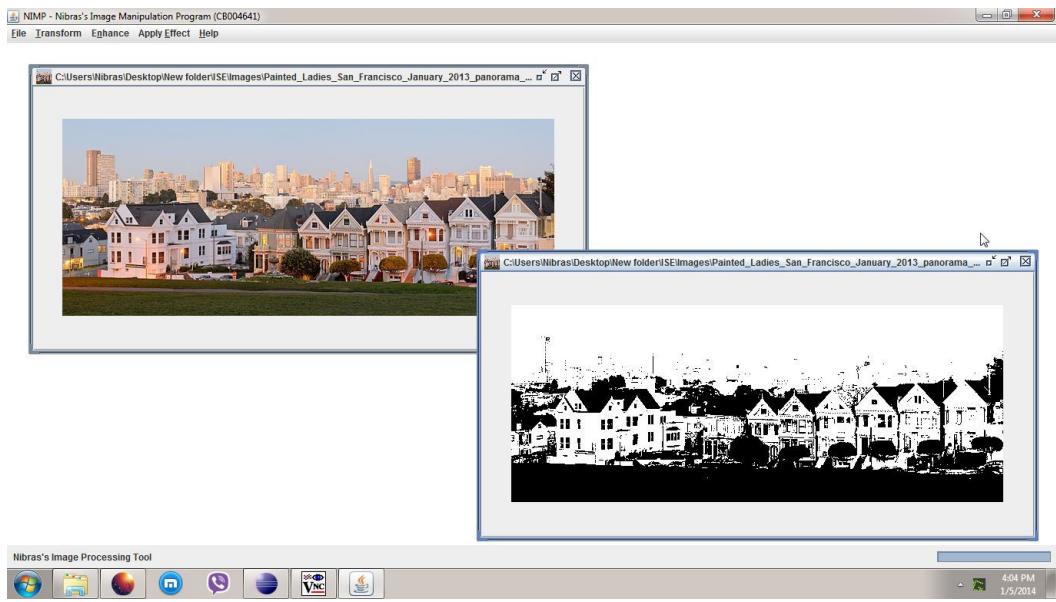


Figure 55: Result after Histogram Equalization

1.5.7 Enhance - Segmentation

This feature can be accessed by clicking Enhance and then Segmentation or by pressing ALT, N and then S. This feature attempts to create a binary image (explained in Transform - Convert - Black & White) where objects are assigned the color black and background is assigned the white color. This feature attempts to do this by using Otsu's automatic threshold determination. This technique is basically a trial and error technique where the program automatically tries out different threshold values (when an image is thresholded using a particular value, all values below this value are considered black and everything above is considered white) for the image and selects the one which creates the minimal spread (Đurović n.d.; Morse 2002, p.1-5; Cigan 2012; Otsu 1979).

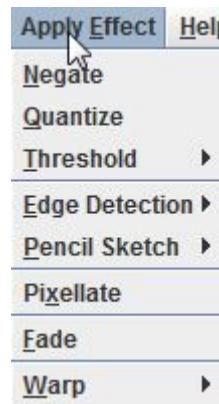
Following shows the image of a range house and then the output of this operation.



**Figure 56: Before (left) and After(right) using Segmentation
(A two segment panorama... 2013)**

1.6 Apply Effects

This menu contains a set of commands which enhance the image or transform the image to create a new image. The techniques may either employ a pixel by pixel manipulation of intensities or change location of pixels to change the image. Most of the features in this menu severely modify the original image and hence lose the original image. However, some of these features can be used to highlight a particular detail of the image while discarding others or to distort the image to create a new digital image.

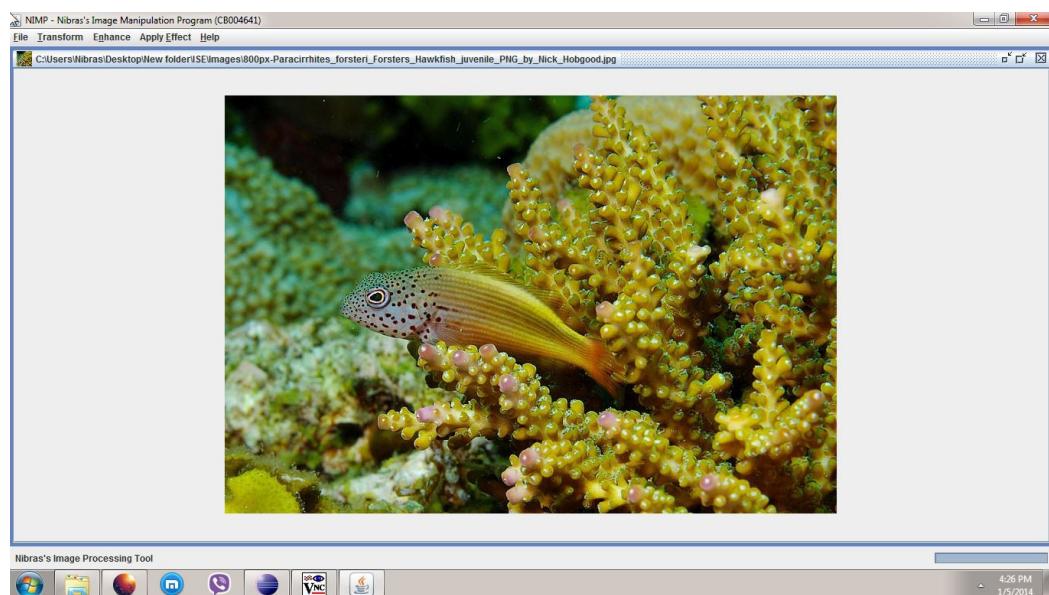


**Figure 57:
Apply Effect
Menu of NIMP**

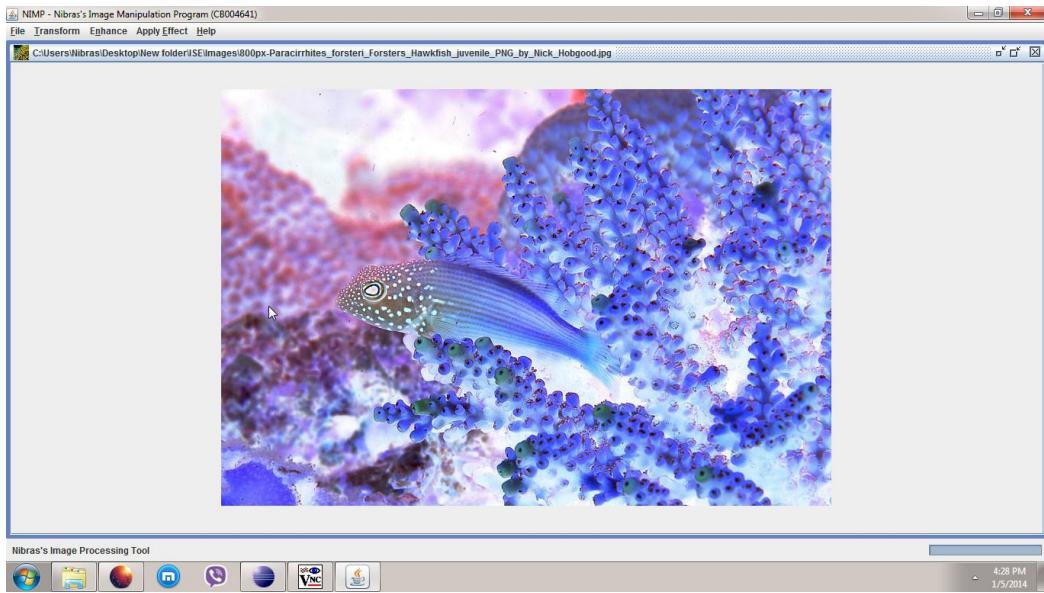
1.7 Apply Effects - Negate

This feature can be accessed by clicking Apply Effects and then Negate or by pressing ALT, E and then N. This feature applies a negative effect to the image. It tries to create a representation of a negative if the image had been capture with a traditional camera. The application achieves this result by negating or rather subtracting the current intensity of a color from the maximum possible intensity for each primary color at each pixel (Amarasinghe n.d.). This can be used to highlight extremely low contrast images. However, the original colors of the image will be lost.

The following shows a camouflaged fish.



**Figure 58: Image before Negation
(*Paracirrhites forsteri Forsters Hawkfish juvenile 2013*)**



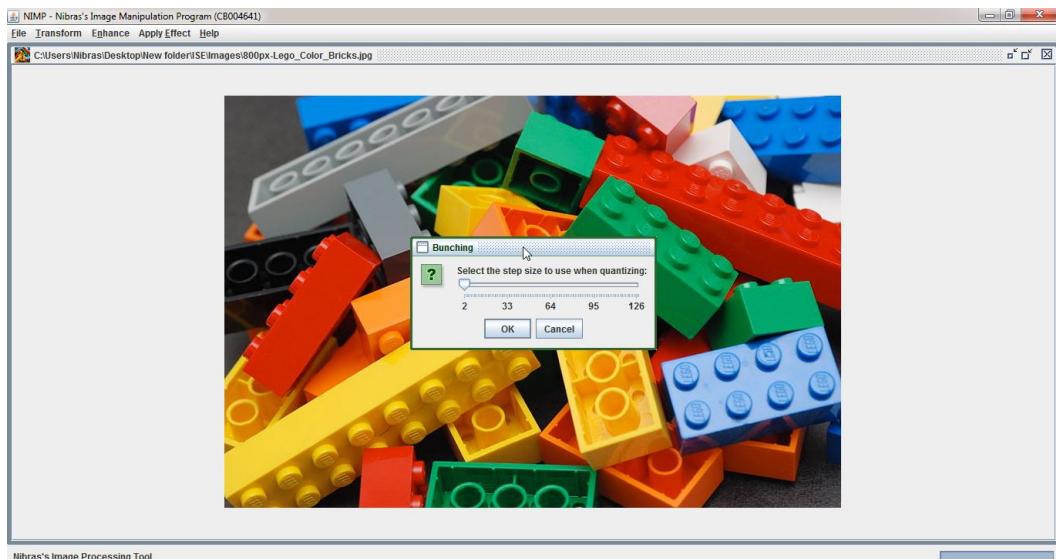
**Figure 59: Image after Negation
(*Paracirrhites forsteri* Forsters Hawkfish juvenile 2013)**

The highlighted images highlights the structure of the fins and lateral lines of the fish highlighting its morphology.

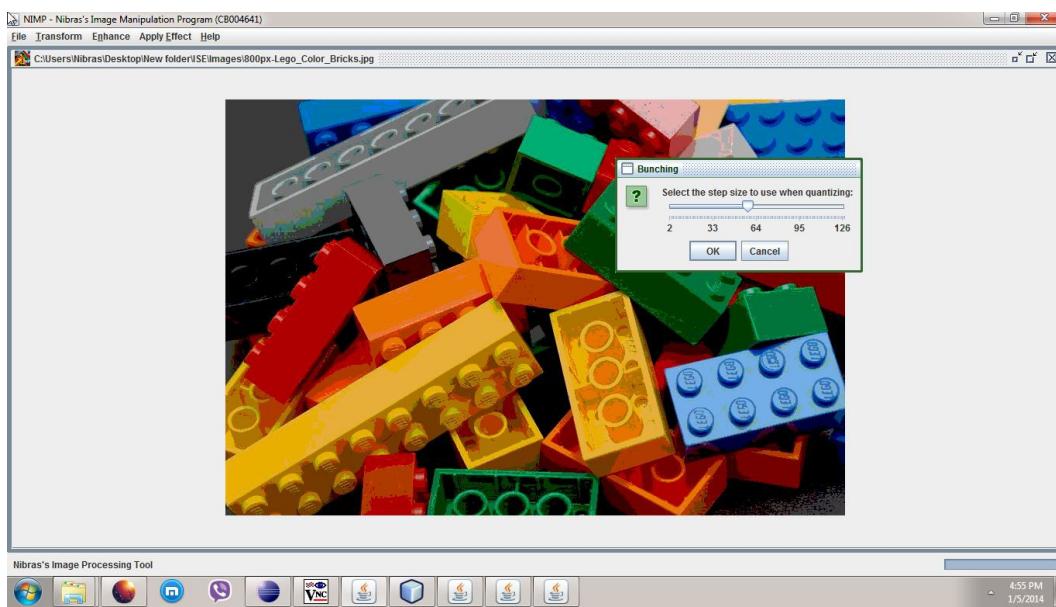
1.7.1 Apply Effects - Quantize

Quantize can be considered the opposite of Contrast enhancement. It attempts to reduce the variation of color intensities by replacing all intensities in a particular range with the middle value of the range. This command can be executed by click Apply Effects and then Quantize or by press ALT, E and then Q.

Once user clicks this, the application will prompt the user to select the size of range and then the entire range of supported intensities will be divided into smaller ranges of specified size (Amarasinghe n.d.). The program will apply the effect as the user moves the slider. Once the desired outcome is reached, user has to click Ok. If user clicks cancel, the changes will be canceled.



**Figure 60: Prompt for Quantize and Image before Quantization
(A pile of Lego blocks... 2007)**



**Figure 61: Image after being Quantized using a Step Size of about 60
(A pile of loge blocks... 2007)**

Same effect being applied after converting image to gray-scale.

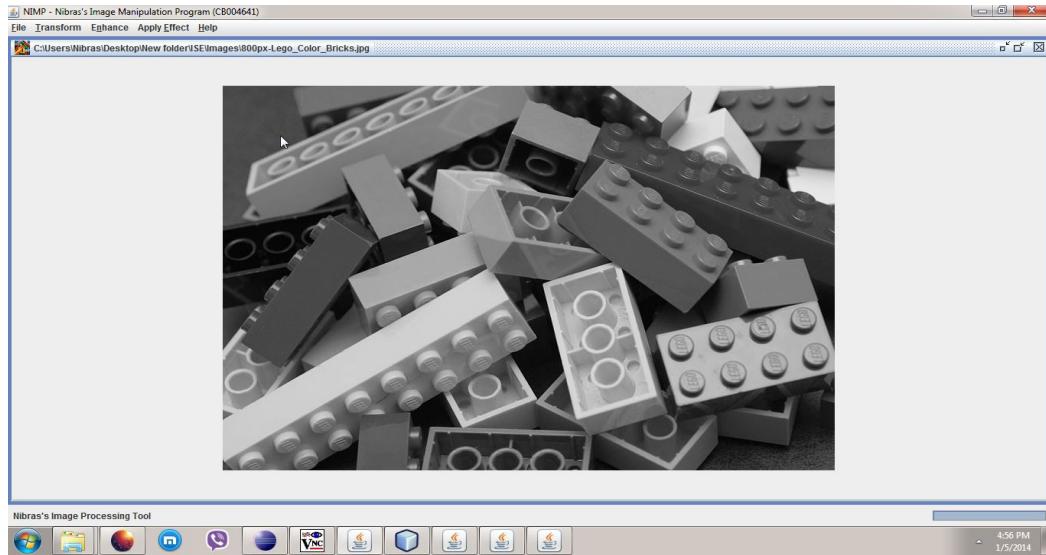


Figure 62: Sample Image for Quantization converted to Gray-scale
(A pile of lego blocks... 2007)

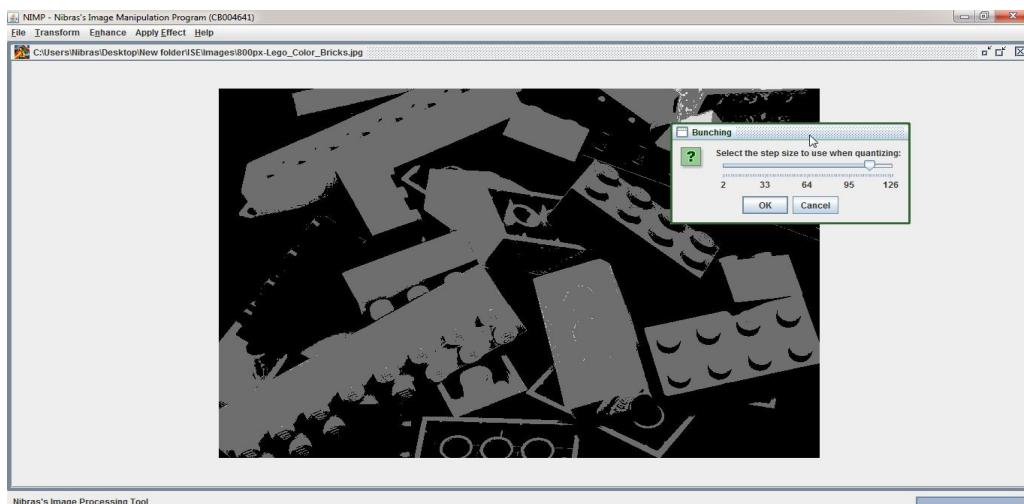


Figure 63: Gray-scale sample image Quantized to about a step size of 100
(A pile of lego blocks... 2007)

1.7.2 Apply Effects - Threshold

Segment and Convert to Black and White features first convert image to gray-scale and then apply particular algorithms.

When an image is thresholded based on a particular value, for every pixel with an intensity above the the particular threshold value, the pixel is assigned the maximum possible intensity and if it is below, it is assigned the minimum possible intensity

(Amarasinghe n.d.; Shih, 2010, pp. 120-122). Since color images in this application use the ARGB model, each pixel consists of three color pixels. When a command from this option is executed, it applies the thresholding to each color separately and then displays the result. When at 128 is selected, the value is considered as 128 or rather around 50% of maximum intensity. When auto is selected, the application applies Otsu's threshold determination (see Enhance - Segment) to each color separately.

Even though this is Mathematically valid, due to the way colors are perceived by human eyes, the results produced are often not accurate. The image must be handled and processed in HSV model to achieve proper thresholding for color images(Aliana and Raof et al., 2010) . However, this is beyond the scope of this project.

This menu can be accessed by clicking Apply Effects, Threshold and at 128 to threshold at 128 or auto to use Otsu's algorithm. Alternatively, these functions can be access by pressing ALT, N and then T and 1 or by pressing ALT, N and then T and a respectively.

A sample image was subjected to these effects and the corresponding outputs are shown below.



Figure 64: Sample Image used for Thresholding
(A variety of corals form an outcrop on Flynn Reef... 2010)



Figure 65: Sample Image after Thresholding at 128
(A variety of corals form an outcrop on Flynn Reef ... 2010)



**Figure 66: Sample Image after Thresholding at value detected Automatically
(A variety of corals form an outcrop on Flynn Reef ... 2010)**

1.7.3 Apply Effects - Edge Detection

At first, the application considers each pixel individually and then selects a square of pixel around the particular pixel and then, it multiplies each of the pixels in this square with values from a set of predetermined values (Amarasinghe n.d.; Đurović n.d.). Sometimes the values generated by this process may be outside the valid range of intensities for a particular color. Therefore, the generated values are clamped to the valid region (by replacing values below valid range with lowest possible value and values above the range with maximum possible intensity (Amarasinghe n.d.; Đurović n.d.). Based on the set of values (called a filter) used for detecting edges, there are multiple edge detection techniques supported by this application.

Each of these edge detection techniques can be accessed by clicking Apply Effect, Edge Detection and then the desired technique or by pressing ALT, E, and then E and then S for Sobel, L then D for Laplacean Dark or L and then L for Laplacean Light. Following is an image with sharp edges.



Figure 67: Image with Sharp Edges to Demonstrate Edge Detection
(Gray-scale image of a brick wall & bike rack 2007)

Each of the following sections briefly describe above techniques and the technique applied to the above images.

Sobel

This is an extremely sensitive edge detection filter.

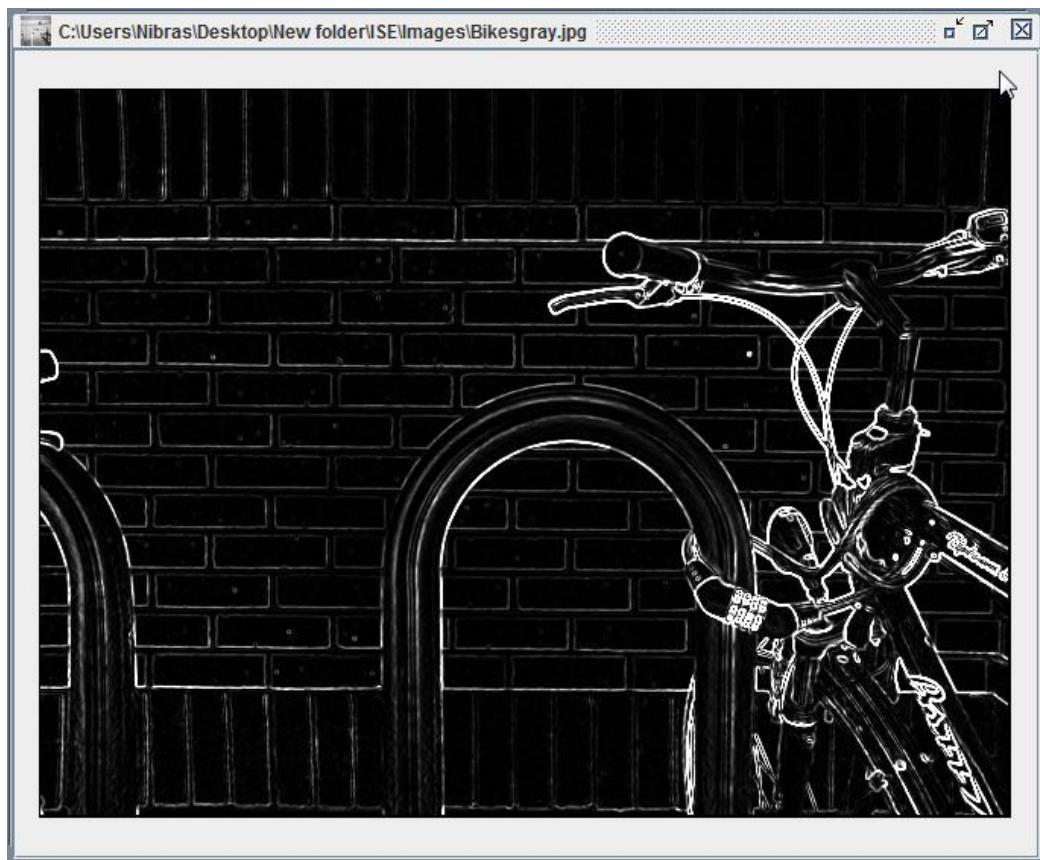
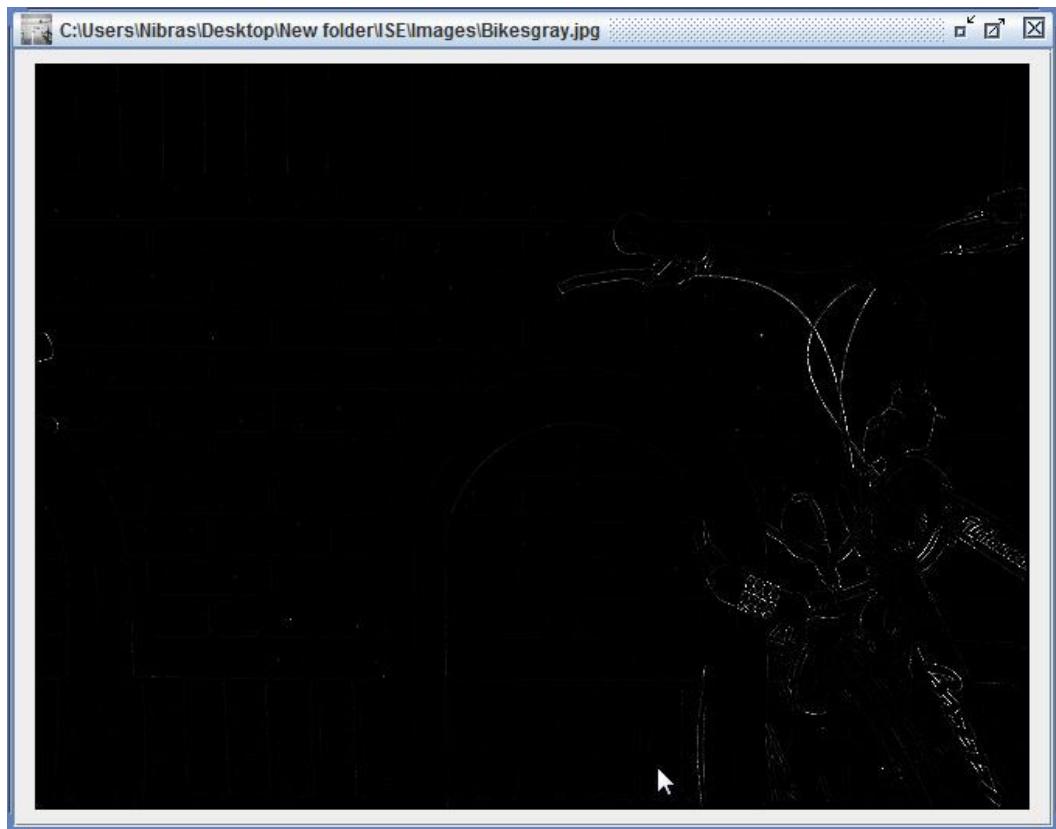


Figure 68: Output of Sobel Edge Detection to Sample Image
(Gray-scale image of a brick wall & bike rack 2007)

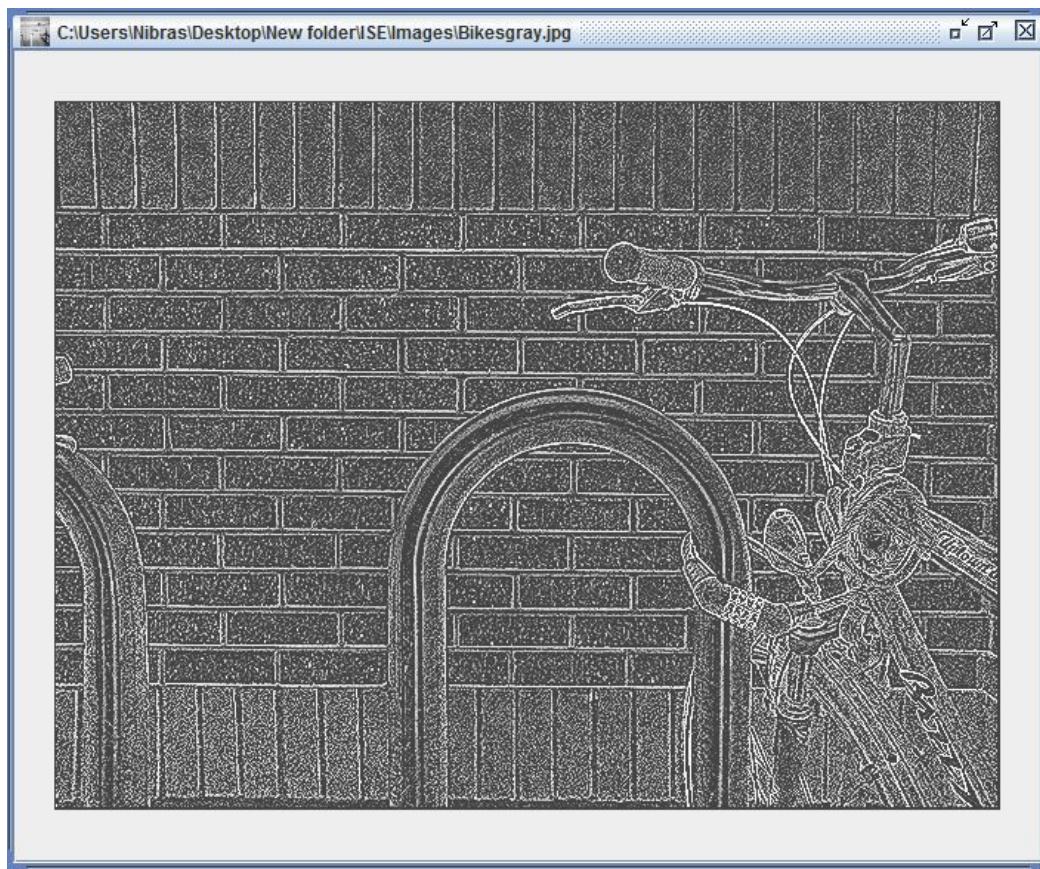
Laplacean Dark and Light

The Dark version darkens the edges while the Light version lightens the edges when detecting edges.



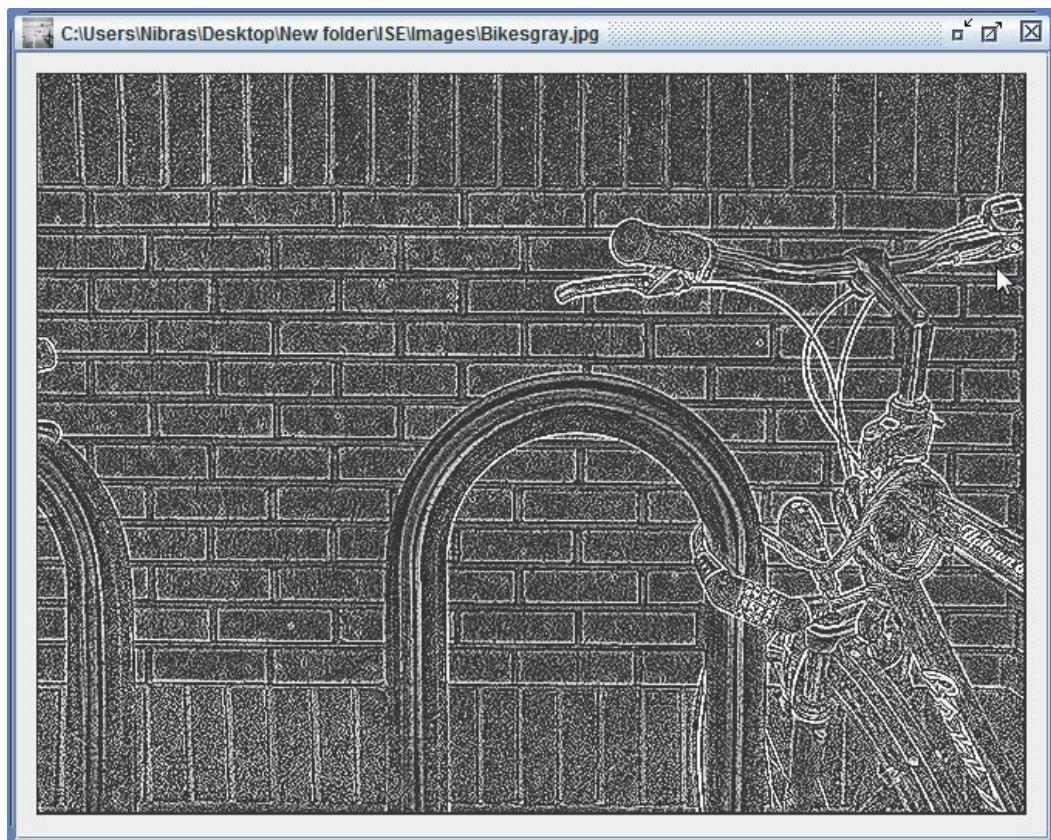
**Figure 69: Output of Laplacean (Dark) Edge Detection to Sample Image
(Gray-scale image of a brick wall & bike rack 2007)**

This figure shows the output of Laplacean dark. However, the visibility is low since color distribution is low. Therefore, the image was subjected Histogram Equalization.



**Figure 70: Enhanced Output of Laplacean (Dark) filter to Sample Image
(Gray-scale image of a brick wall & bike rack 2007)**

Below image shows enhanced output after laplacean light edge detection.

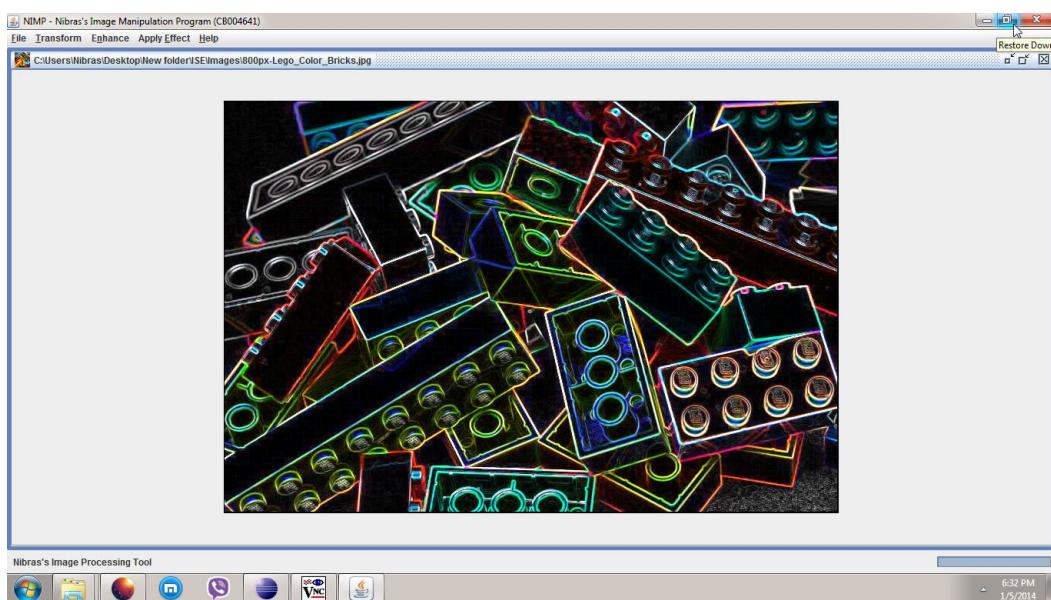


**Figure 71: Enhanced output of Laplacean (Light) filter to Sample Image
(Gray-scale image of a brick wall & bike rack 2007)**

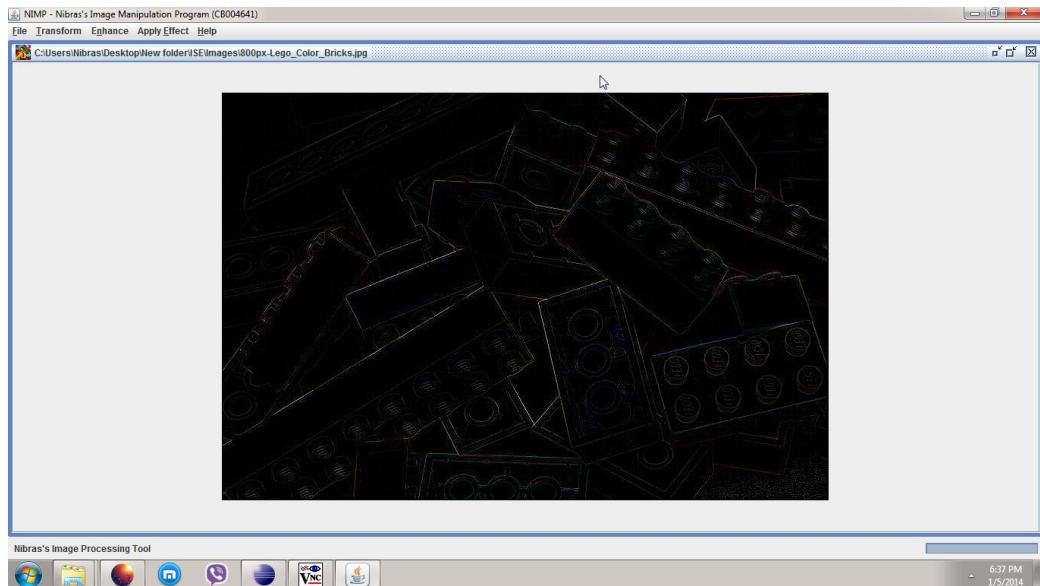
The following color image was also subjected to these edge detection algorithms. Edge detection is applied to each color separately and the result is obtained by combining them.



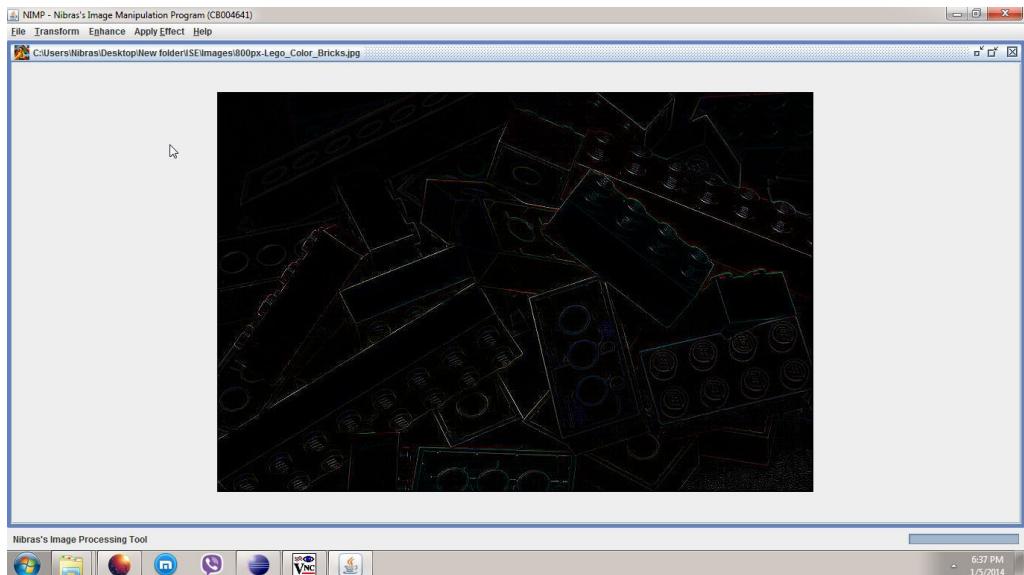
**Figure 72: Sample Color Image for Edge Detection
(A pile of Lego blocks 2007)**



**Figure 73: Output of Sobel Operator to Sample Color Image
(A pile of Lego blocks 2007)**



**Figure 74: Output of Laplacean (Dark) Edge Detection to Sample Color Image
(A pile of Lego blocks 2007)**



**Figure 75: Output of Laplacean (Light) Edge Detection to Sample Color Image
(A pile of Lego blocks 2007)**

1.7.4 Apply Effects - Pencil Sketch

This command attempts to create a pencil sketch of the given image. Since traditionally pencils supports only a single color, first the application converts any color image to grayscale before continuing. Once this command is executed, the application will prompt the user to select a shade of gray to be used as the lightest possible shade of the pencil.

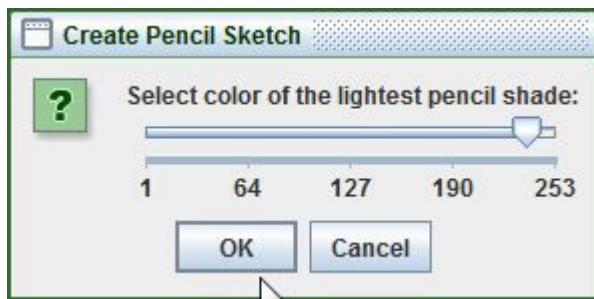


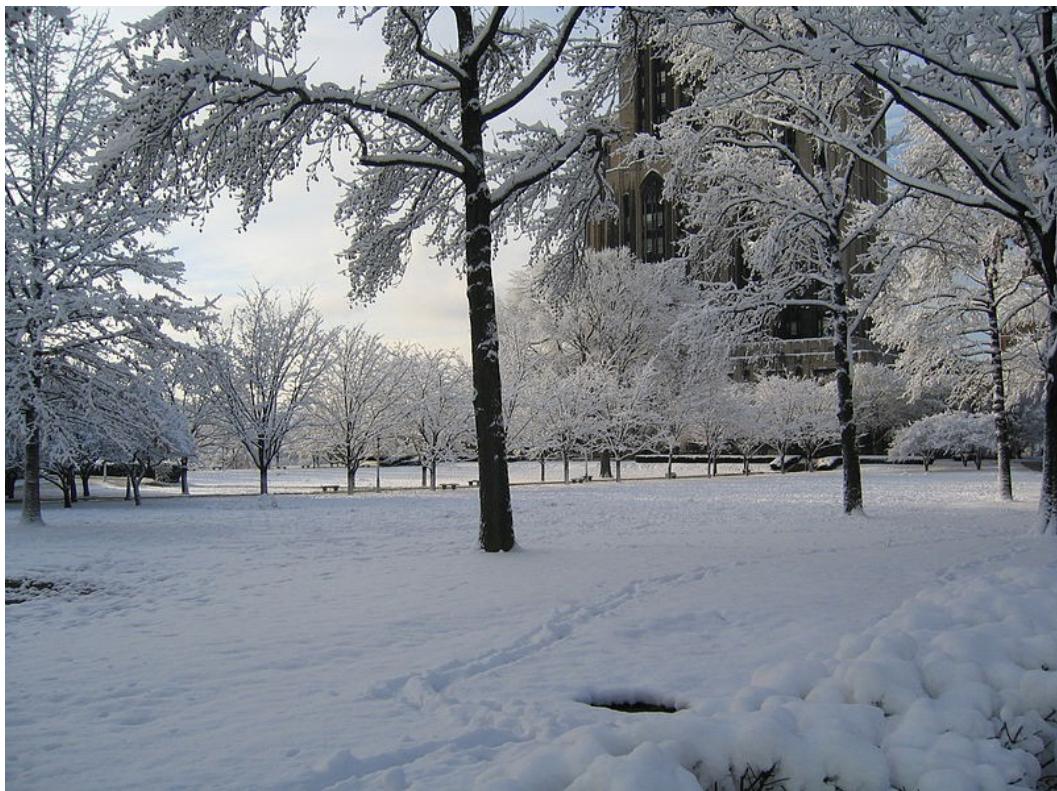
Figure 76: Prompt to Choose the Lightest Pencil Shade

It is essential that user selects an appropriate shade based on the nature of image. A very light shade should be used for images with dense shades or rather textures. A darker shade is more suitable for line diagrams and such.

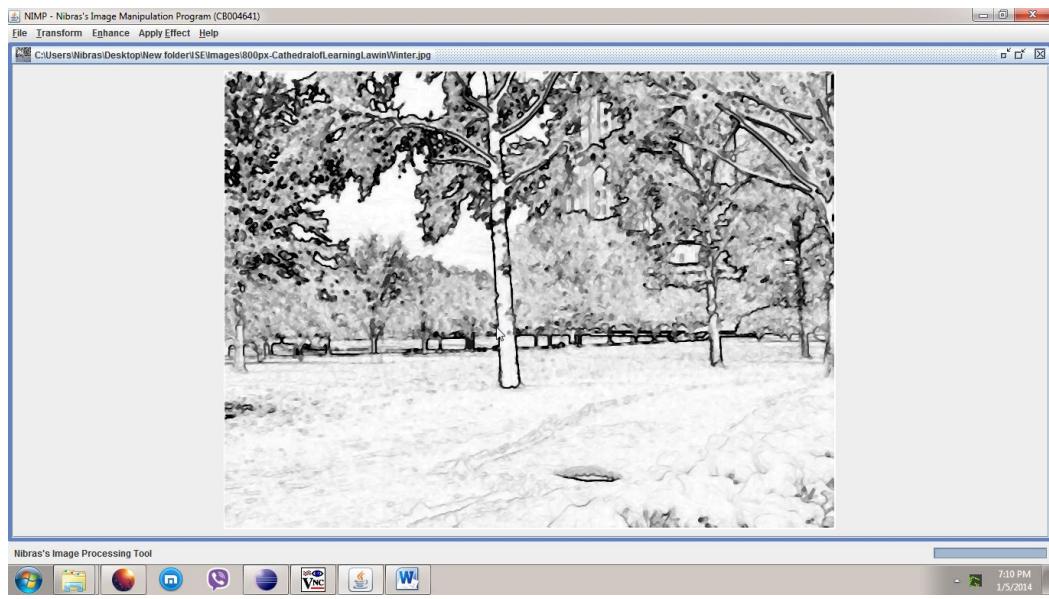
It first blurs the image to thicken the edges and then, it applies an edge detection filters (see Enhance - Sharpening and Apply Effects - Edge Detection) which results a set of values each corresponding to an individual pixel in the image and determining the gradient of color change in relation to neighbouring pixels (edges result in a steeper gradient)(Amarasinghe n.d.; Đurović n.d.). Using this set of values, the application detects edges and then sets the background pixels to white(simulating a paper) and sets the edges to different shades of white depending on the steepness of the gradient (simulating more pronounced and lighter pencil shades)(Amarasinghe n.d.; Đurović n.d.). Finally, the application smoothes the image again to simulate smudged and thick pencil lines(Amarasinghe n.d.; Đurović n.d.).

Each of these sketching techniques can be accessed by clicking Apply Effects, Pencil Sketches and then the desired technique or by pressing ALT, E, and then P and then S for Sobel, L then D for Laplacean Dark, L and then L for Laplacean Light or J for Jin Zhou's algorithm.

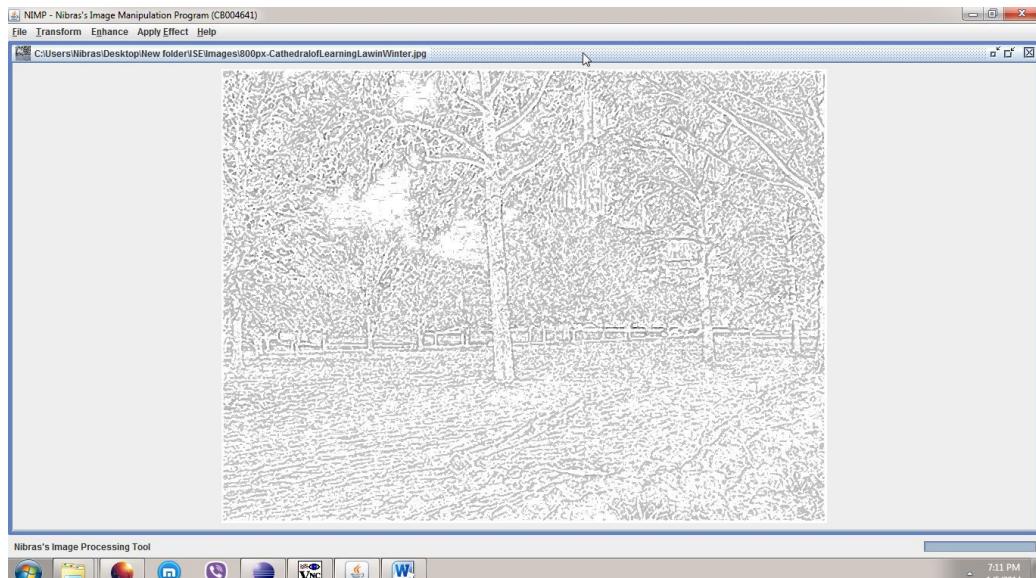
Following shows a sample image which was used to demonstrate the pencil sketching and then results of each sketching algorithms are shown afterward.



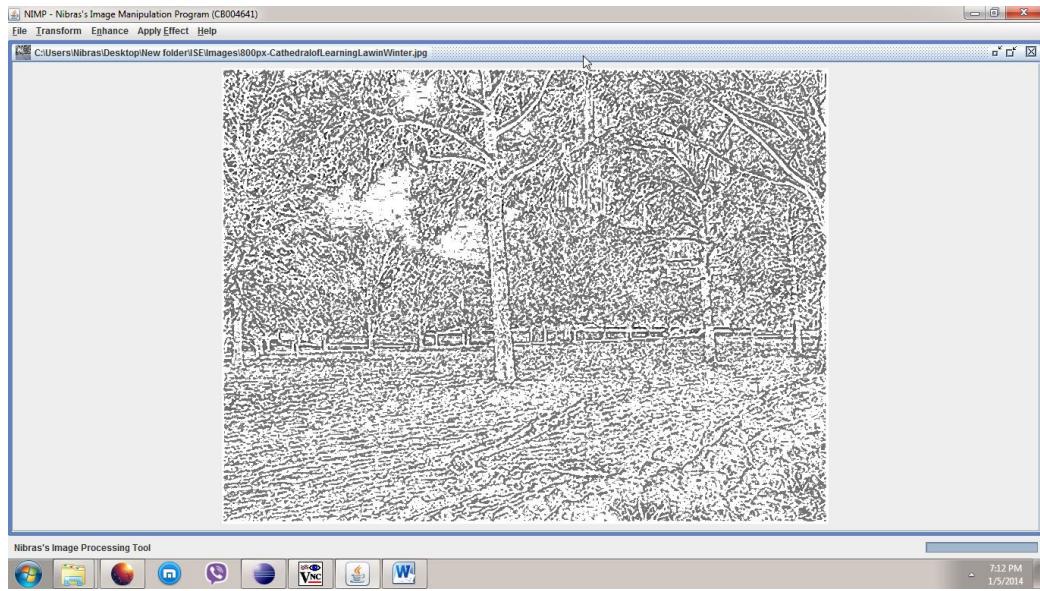
**Figure 77: Original Image used for Pencil Sketch Demo
(A cathedral 2003)**



**Figure 78: Pencil Sketch of Sample Image using Sobel Operator
(A cathedral 2003)**



**Figure 79: A Pencil Sketch of Sample Image using Laplacean (Dark)
(A cathedral 2003)**



**Figure 80: Pencil Sketch of Sample Image using Laplacean (Light)
(A cathedral 2003)**

1.7.5 Apply Effects - Pixelate

Once this feature is used, the program divides the image into rectangles of a specified size and replaces the colors of all pixels within each rectangle with a particular color present towards the mid of the rectangle. If a person looks at a digital image close enough, he maybe able to notice the small pixels that make up the image(Amarasinghe n.d.; Đurović n.d.). Similarly, when this technique is applied, the image is converted to simulate this image except the visible pixel in the resultant image is actually a rectangle of actual pixels with same color (Amarasinghe n.d.; Đurović n.d.).

The following image was selected to demo this effect.



Figure 81: Sample Image used for Pixelation
(A lioness roars... 2010)

Once this command is executed, the program will prompt to enter the size of the result images apparent pixels in terms of actual pixels. User may select “Keep to scale” to get square pixels instead of rectangle pixels in the resultant image. This feature also supports live previews and the effect will be immediately applied to the image as the user selects different row and column sizes. Once the desired effect is reached, the user may click Ok. If the user clicks Cancel, the image will be restored to its previous state.

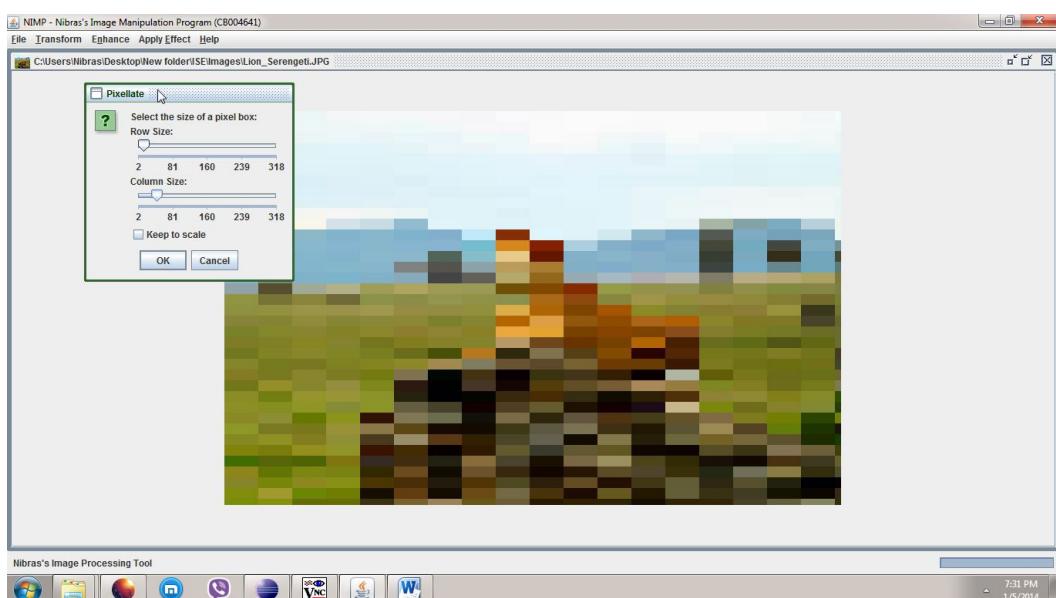
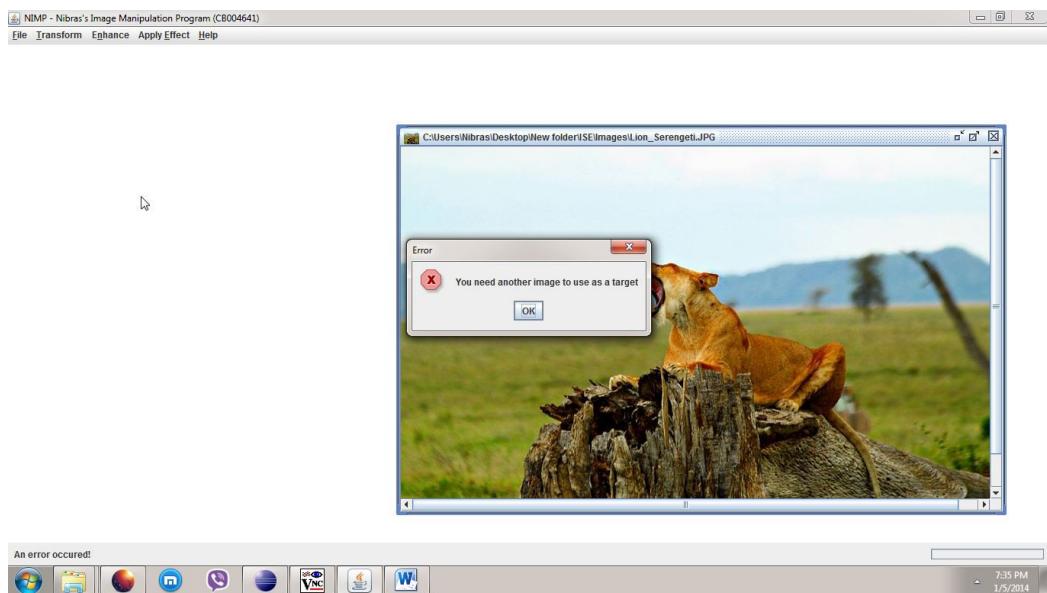


Figure 82: Output of Pixelation Effect with Sample Image
(A lioness roars... 2010)

This command maybe accessed by clicking Apply Effects and then Pixellate or by pressing ALT, E and then X.

1.7.6 Apply Effects - Fade

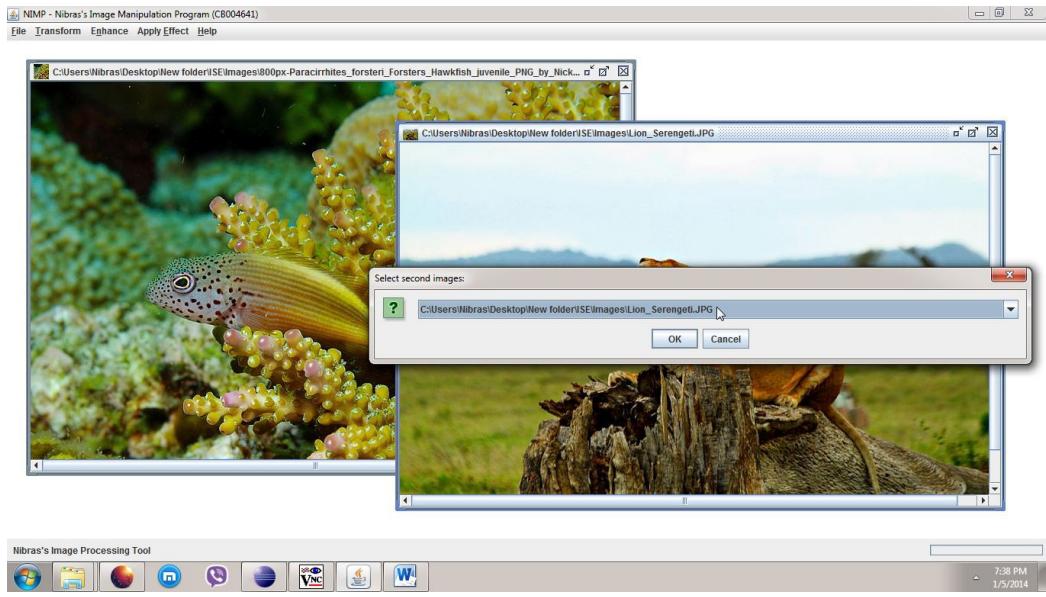
This effect works by creating an “average” of two images (Amarasinghe n.d.; Đurović n.d.). Since this effect involves two images, the application expects at least two images to be open. If two images are not open, it will show an error.



**Figure 83: Warning showing that at least two images must be open for fade.
(A lioness roars... 2010)**

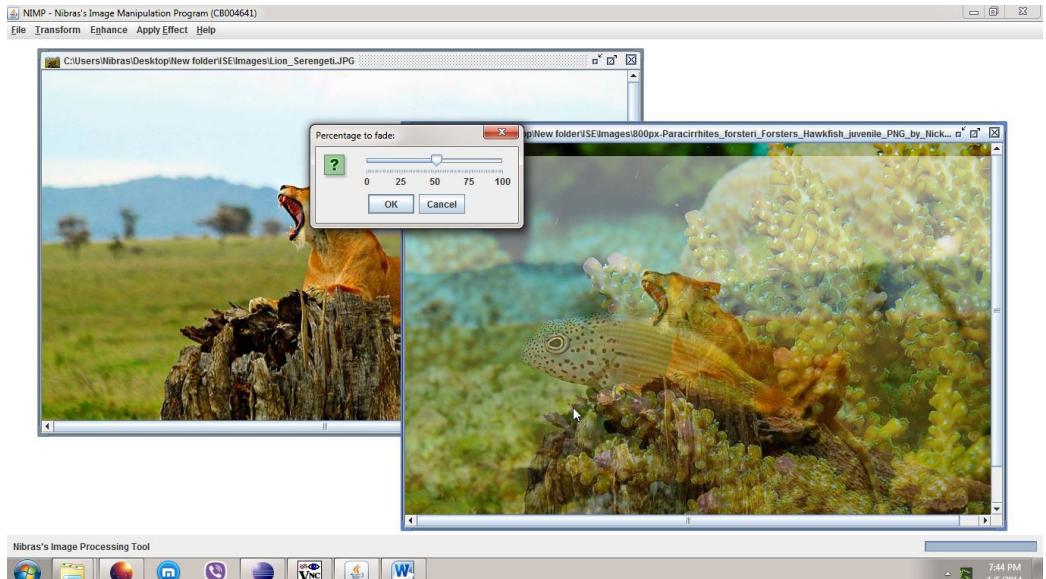
When using fading, the user has to select both a source image and a target image. After opening both source and target images, the user has to select the source image and executed the fade command. This maybe done by clicking Apply Effect and then Fade or by pressing ALT, E and then F.

Once the command is executed, the application will prompt the user to select the second image from a dropdown of open images.



**Figure 84: Prompt to Select Target Image for Fading and Source Images
(A lioness roars... 2010, *Paracirrhites forsteri* Forsters Hawkfish juvenile. 2013)**

Then, the user will be prompted by the application to choose a percentage for fading. Selecting 100% will result in the target image and selecting 0% will result in the source image. Anything above 50% will result in an image with more weight to target image and vice versa. This feature also supports live previews and will alter the source image depending on currently selected percentage of fading. If user clicks Ok, the last selected percentage of fading will be used. Otherwise, the image will be restored to its previous state.



**Figure 85: Prompt to Select Fade Intensity and Output
(A lioness roars... 2010, *Paracirrhites forsteri* Forsters Hawkfish juvenile. 2013)**

(Note: If target image is smaller, the source image's original pixels will be used where corresponding target images were not available. The application does not currently support a target image larger than source.)

When this command is executed, the application applies weighted averaging each pixel from the source image to its corresponding pixel in the target image. This technique works by multiplying the target image pixel with the percentage selected by user and then source image pixel with (100-user selected value) % essentially created a weighted average of both pixels using a weight specified by the user(Amarasinghe n.d.; Đurović n.d.).

1.7.7 Apply Effects - Warp

This sub menu lists a set of distortions that create a specific output image. There are two types of warps supported by this application. Each of them can be accessed by clicking Apply Effects, Warp and then the name of the particular effect or by pressing ALT, E and W and then, F for Fish Eye, B for Bulge or T for Twirl.

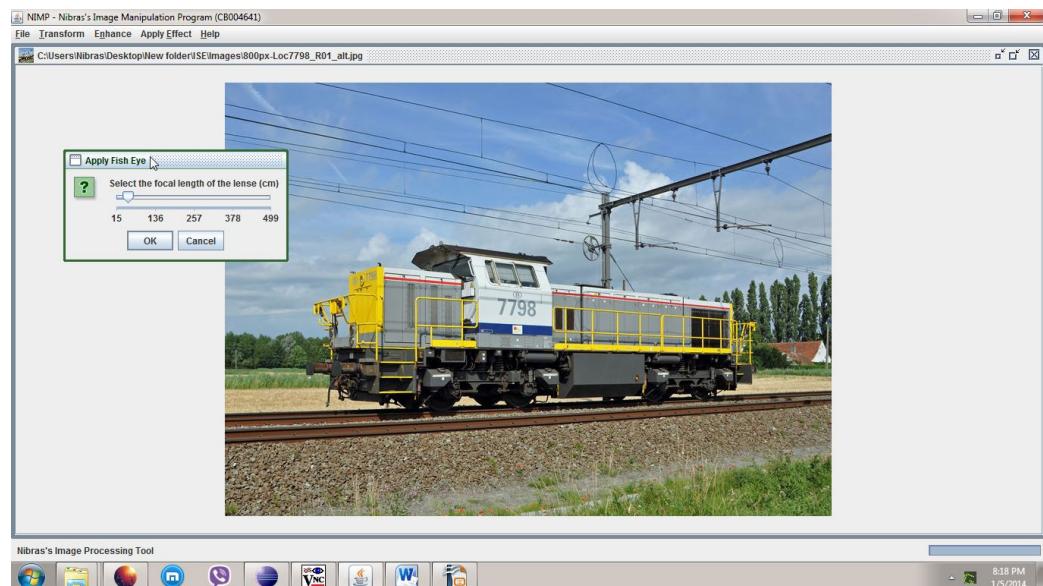
Mathematically, Fish Eye, Twirl and Bulge attempt to distort the image by choosing the center of the image as origin and then considering the position as a 2D cartesian plane (The Supercomputing Blog, n.d.). Then, the coordinates of each pixel is converted to polar form and manipulated to create the desired effect resulting in a new position for each pixel.



**Figure 86: Sample Image used for Warping
(Diesel locomotive 2010)**

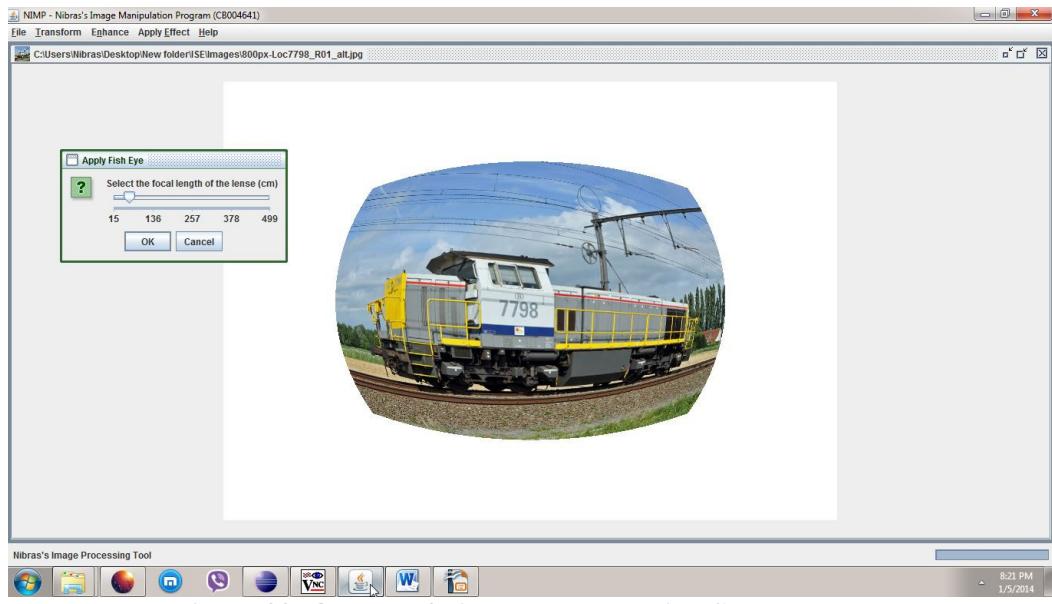
Fish Eye

This is basically a lens effect. Once this effect is chosen, the user will be prompted to choose the focal length of the target lens whose effect to simulate.



**Figure 87: Prompt to choose the focal length of the lens to simulate
(Diesel locomotive 2010)**

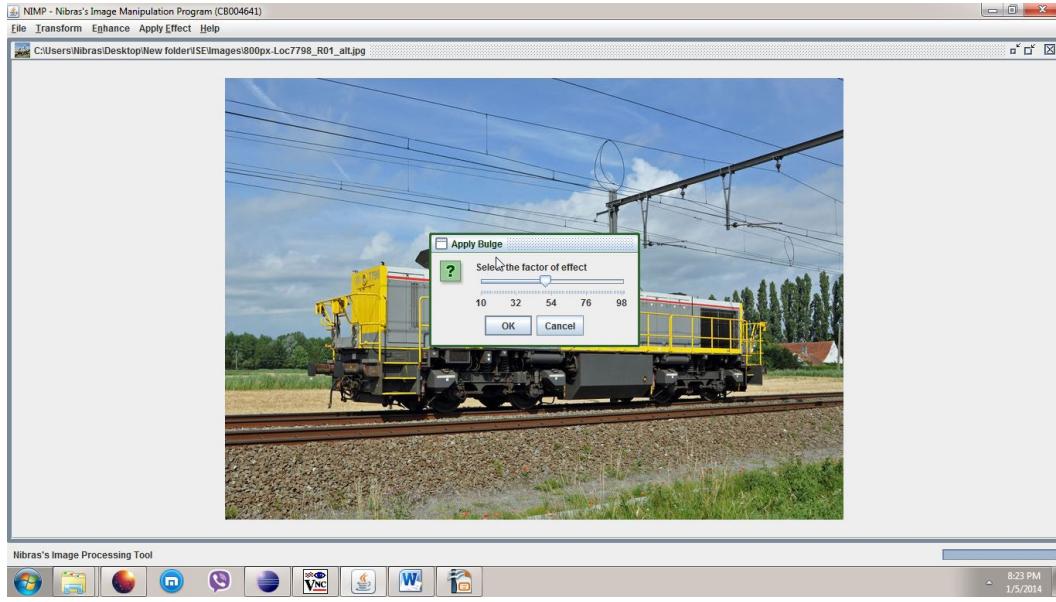
As the user selects different focal lengths, the effect will immediately be applied to image and the output will be shown. User may click Ok to continue or Cancel to discard the effect.



**Figure 88: Output of Fish Eye Warp using Sample Image
(Diesel locomotive 2010)**

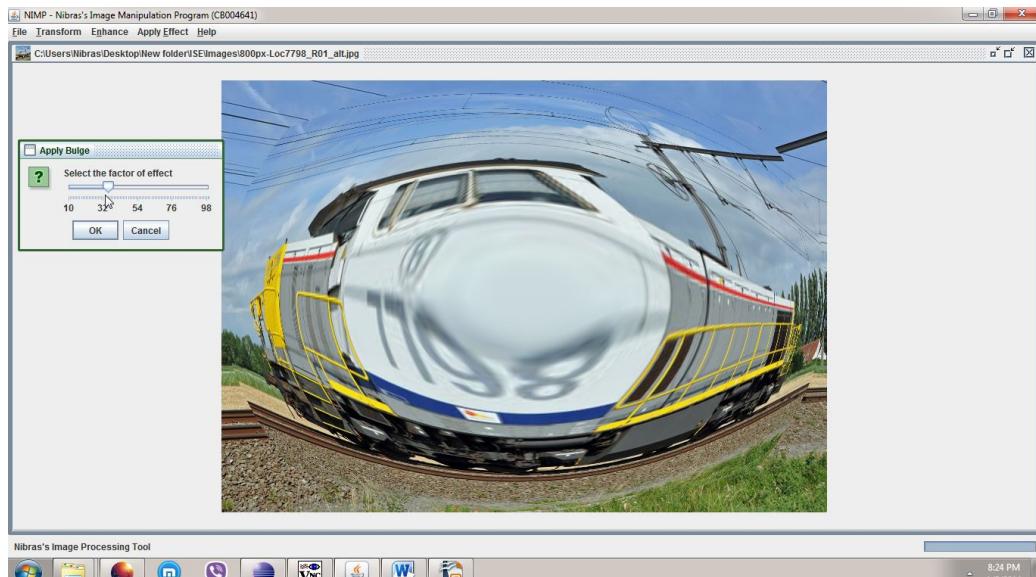
Bulge

This attempts to create a bulge in the image centered at the center of the image. Once user selects this, user will be prompted to choose an intensity.



**Figure 89: Prompt to Select Intensity of Bulge Effect
(Diesel locomotive 2010)**

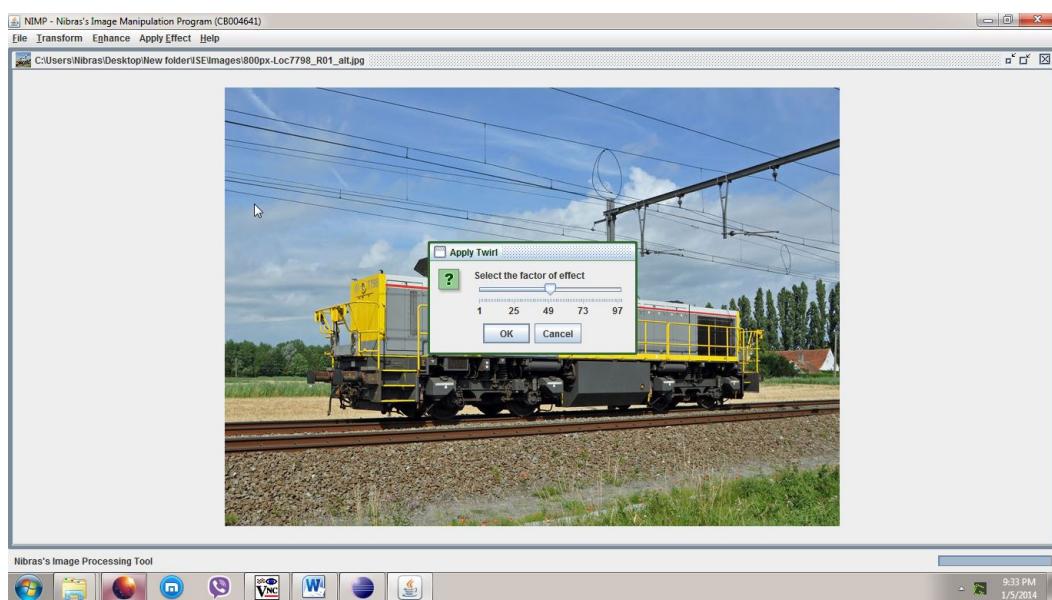
As the user selects different intensities, the effect will immediately be applied to image and the output will be shown. User may click Ok to continue or Cancel to discard the effect.



**Figure 90: Output of Bulge Warp
(Diesel locomotive 2010)**

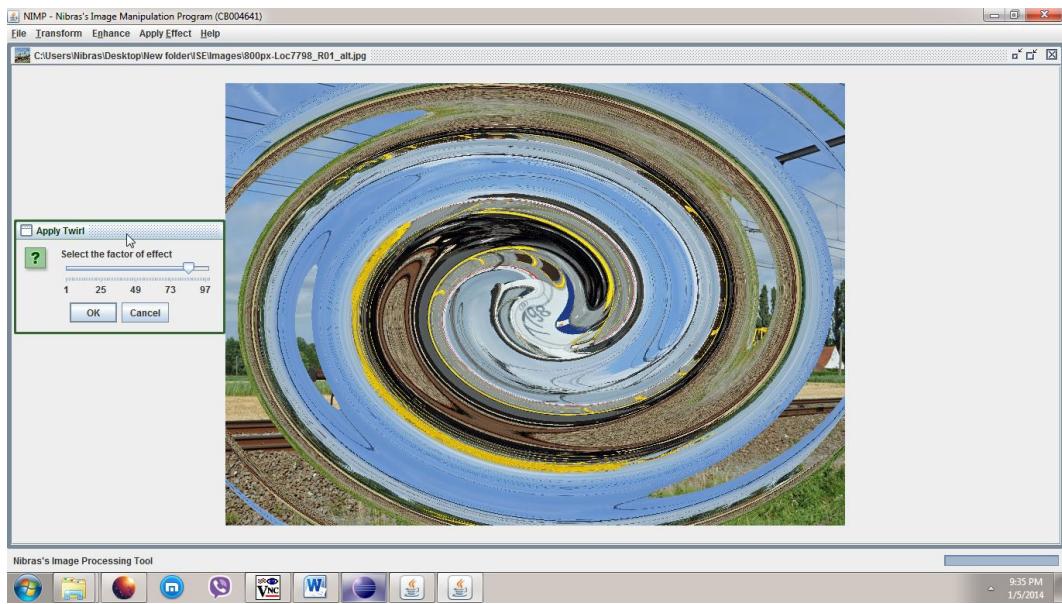
Twirl

This attempts to rotate each pixel about the center depending on its distance from the center (The Supercomputing Blog, n.d.). Once user selects this, user will be prompted to choose an intensity.



**Figure 91: Prompt to Select Intensity of Twirl Effect
(Diesel locomotive 2010)**

As the user selects different intensities, the effect will immediately be applied to image and the output will be shown. User may click Ok to continue or Cancel to discard the effect.



**Figure 92: Output of Twirl Warp
(Diesel locomotive 2010)**

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