

RHODES UNIVERSITY
Department of Computer Science

Computer Science Honours

COMPUTER SCIENCE HONOURS PROJECT PAPER

IMAGE PLUG-INS FOR GIMP

By: Vera Kukic

Supervisors: Shaun Bangay, Adele Lobb and George Wells

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Abstract

This paper describes the development of emerging colour interpolation techniques as GIMP plug-ins: Colouring Greyscale Images and Image Inpainting. The plug-ins will offer new image manipulation functionality that will enhance the capability of GIMP. Colouring Greyscale Images refers to the ability to change the 'mood', colour information, of a greyscale image. The colorizing of the greyscale image is done by transferring colour between a source colour image and the destination greyscale image. Image Inpainting is the process of restoring photos/images to its original state in an undetectable manner.

Introduction

The objective of this project is exploring colour interpolation plug-ins in the GIMP framework. The objective is to develop colour interpolation plug-ins specifically for colourizing greyscale images and image inpainting into the most popular, wide spread open source image manipulation package known as GIMP. The research merit is in introducing emerging colour interpolation functionality into a prolific graphics package.

There is a great demand for colourizing. This involves altering an image's colour and image restoration. Human interaction is an important part of both of these processes and as a result careful HCI design is required. The human input is required to determine what colours go where. The user thus decides what colours from the sources colour image should be applied to different areas of the destination greyscale image. Human input is again required in selecting the areas of the image that need to be restored or removed.

Background

In order for the main GIMP program to invoke the developed plug-in, the plug-ins need to implement a specified interface. Each plug-in will have a unique GUI depending on its functionality. GIMP interfaces with plug-ins by searching for files of the appropriate format and incorporating them into its menu structure. The search is only done across the plug-in sub-directories. The position where the plug-in is incorporated into the GIMP structure is defined within the plug-in. An example of the code used to do this is shown in Figure 1.

```
//register plug-in in the PDB
gimp_install_procedure (PLUG_IN_NAME,
    "Picks up colour distribution from colour image, and applies it to the greyscale image.",
    help_string,
    "Vera Kukic",
    "g99k0588@campus.ru.ac.za",
    "2003",
    N_("<Image>/Filters/Colors/Map/Colourize"),
    "RGB*, GRAY*",
    GIMP_PLUGIN,
    nargs, nreturn_params, args, return_params);
```

Figure 1: Registering the Plug-in

Traditionally, the development of GIMP plug-ins is done using the C programming language, although perl libraries also exist. Every C program has a main function and it is the first function that is called when the program is executed. When developing plug-ins for GIMP the main function is simply declared as MAIN() and it is defined in the libgimp/gimp.h file. This calls the gimp_main function and sets up the signal handling and the communication between the plug-in and GIMP. Plug-ins are queried by GIMP on start-up, and they need to register themselves in the procedural database (PDB). Every plug-in needs to have: #include libgimp/gimp.h, PLUG_IN_INFO, main, a query function with a call to gimp_install_procedure and a run function which sets the status code return value.

The first plug-in is based on recent work by Welsh et al titled “Transferring Color to Greyscale Images”. This paper describes a general technique for colouring greyscale images by transferring colour between the source (colour image) and the destination (greyscale image) using swatches. A swatch is a selected rectangular region of pixels that stores the selected information from the colour image and then is used to transfer this information to the selected region on a greyscale image. Welsh builds on ideas from the paper by E. Reinhard, M. Ashikhmin, B. Gooch and P. Shirley (2001) that describes the method of colour transfer between images. Reinhard et al (2001) describe a simple statistical analysis that is used to impose one image’s colour characteristics to another. The idea is to minimize the human effort in colouring greyscale images. Instead of choosing colours from a RGB palette to colour individual components the entire colour (mood) is transferred from the source image to the target image by matching luminance and texture information between the images. Only the chromatic information is transferred.

The applications of efficient and easy to use image colourization techniques are significant in terms of providing better colour for old family photos. Colourizing not only adds visual appeal but in context provides immediate human understandable information. The technique described by Welsh et al involves matching the tri-dimensional distribution of colour value between images and then transforming the colour of the target image to match the distribution of the source image. Greyscale images are one dimensional and only luminance channels can be matched between the two images. A single illuminating value can represent different parts of the image thus the statistics within a pixel’s neighbourhood are used to guide the matching

process. The neighbourhood statistics are computed over the greyscale image and they consist of standard deviation of the luminance values. Swatches are used to allow users to selectively transfer colour. Swatches allow for context colouring, thus colour is transferred from the selected region of the colour image to the selected region of the greyscale image. Swatches prevent incorrect colourization of the greyscale image by limiting the area within which the colour is being transferred. The colour is assigned by comparing pixels of the greyscale image to those of the target swatch using the distance metric L_2 . The L_2 distance metric is Euclidean distance or $(L_2)^2 = (x_1 - x_2)^2 + (y_1 - y_2)^2$. This equation calculates the distance between two points. The metric distance L_2 is used to measure texture similarity within an image.

The general procedure requires each image to be converted into lab colour space. Ruderman et al (1998) developed the lab space to minimize the correlation between the three axes of the colour space. l is the achromatic luminance channel and a and b are the two chromatic channels corresponding to yellow-blue and red-green opponent channels. Changes made in one channel should minimally affect the other channels. The lab space is logarithmic and thus uniform changes in the channels are equally detectable. The lab colour space was developed to resemble the human visual perception. Each pixel in the greyscale image is compared to the colour image to find the best match using luminance and neighbourhood statistics. When the best match is found a and b chromaticity values are transferred to the greyscale image while the luminance value remains unchanged.

To make the procedure of colouring greyscale images easier for users swatches are used between the two images. This allows the user to choose what colour to transfer between the images using the swatches. The L_2 metric is used to find texture matches within the greyscale image. This method allows the user to transfer colours from any part of the image to a select region even if the luminance and texture levels are greatly different.



Figure 2: Use of Swatches to Colourize

The second plug-in refers to the “Image Inpainting” paper by M. Bertalmio, G. Sapiro, V. Casseles and C. Ballester (1999). This paper describes inpainting, which is the technique of removing artefacts or undesirable elements from an image in an undetectable manner. Inpainting is a term used by restorers that describes the process of retouching damaged paintings. The application of this plug-in would be the restoration of damaged paintings and photographs, removal of superimposed texts and removal/replacement of selected objects. The user selects the region to be restored and then the algorithm automatically fills-in the region using the information that surrounds the selected area. Neighbourhood statistics are used to match texture and colour to aid in filling the damaged area. Multiple selections can be done at the same time.

Current Status

The interface for the first plug-in (transferring colour to greyscale images) has been designed and implemented using the gtk, which is the GIMP interface API. Before attempting this task I developed a detailed algorithm for the process of transferring colour from one image to another. I have also developed an algorithm for my second plug-in, Image Inpainting.

The user will interact with the plug-in using the following interface.

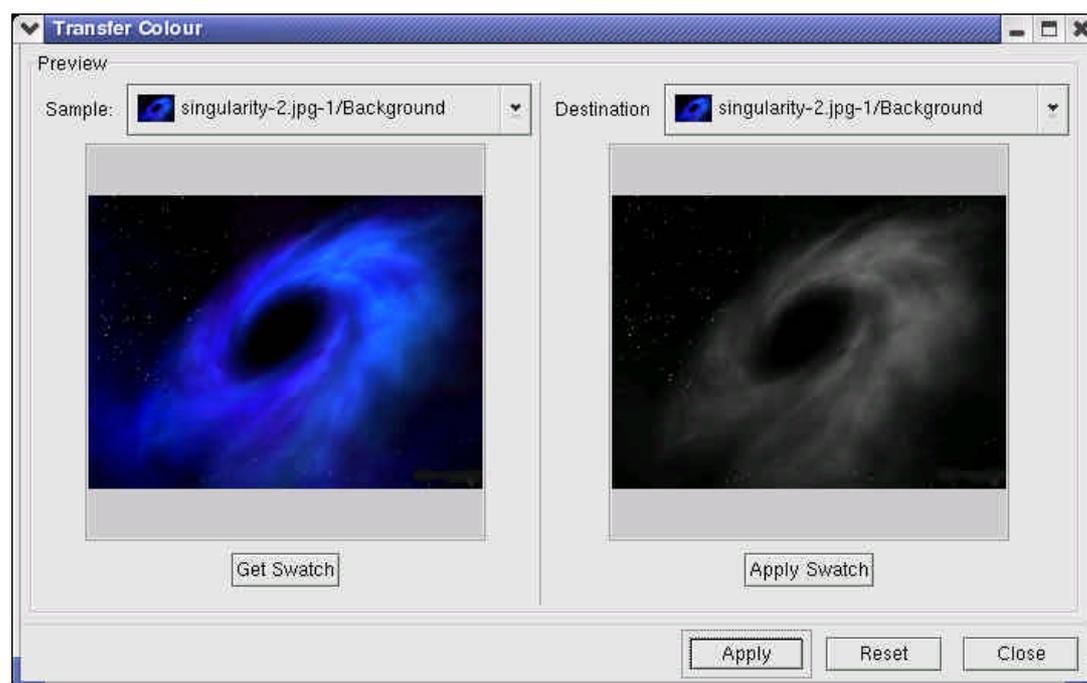


Figure 3: User Interface for Transferring Colour to Greyscale Images

To make a selection on the colour image the user will need to click on the Get Swatch button and then drag a rectangular shape over the area of pixels that needs to be copied. The colour information of those pixels will be copied into a swatch. Once this is done the user will proceed to click on the Apply Swatch button and select a region on the greyscale image that is to contain the colour information from the previous selection. By releasing the selection chosen the colour information will be transferred from the swatch of the original image onto the greyscale image, thus colourizing it. This process is repeated several times until the entire greyscale image is colourized. The Apply button refreshes the original image with the changes that have been made to it in the destination preview. The Reset button undoes any changes that have been made to the destination greyscale image.

The next step in my research is to implement the algorithm for transferring colour to greyscale images. Both of the images are converted to the lab colour space. This is done by retrieving the RGB values of the image. To convert the RGB values to the lab colour space matrix manipulations need to be carried out. Firstly the RGB values are converted to the XYZ tristimulus values. The second procedure is to convert the XYZ tristimulus values to the LMS cone space. The lab colour space is a transform of the LMS cone space. The last transformation involves the conversion from the LMS cone space to the lab colour space. The next step is to do colour processing. This is the actual transfer of one images look and feel to the other. This involves the selection of colour areas from the source image using swatches and the transfer of this information to the destination greyscale image. The mean and standard deviation of each of the channels for both images is calculated. The results must be transferred back to RGB values so that they can be displayed. After the algorithm is implemented successfully, I will test it and start introducing added features and extensions to the plug-in. This added functionality will allow the plug-in to be used on smaller surfaces (thus decreasing the L_2 metric) with similar textures and luminance. To achieve best results the images that are used must be similar in composition. If time permits I will use the same process to develop and implement my second plug-in, Image Inpainting.

Expected Outcomes

The final product of this project will be additions to the GIMP image manipulation package. This project will result in workable and easy to use plug-ins for GIMP. Based on image colour interpolation theory these plug-ins will have colourizing and artefact removal applications.

Conclusion

This project will add relevant and powerful features to the GNU Image Manipulation Package. It will also allow the user to have more manageable and usable functions for image interpolation.

References

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