Logical Creations Education Research Institute
LC INTERNATIONAL JOURNAL OF STEM
E-ISSN: 2708-7123
Web: www.lcjstem.com | Email: editor@lcjstem.com
Volume-04 | Issue-04 | December-2023

Producing of High Quality Colored Images using Scalable Image Processing Techniques

Mohammed Rasool Jawad
Department of Network Technology and Information Systems, University of Babylon, Babylon-Iraq.
mohammed.rasool@uobabylon.edu.iq

DOI: 10.5281/zenodo.10594220

ABSTRACT

One of the many digital approaches that came from the image processing domain is picture enhancement. These approaches are employed to enhance the perceptibility of images, or to transform the image into a format more suitable for human or machine analysis, and to highlight intricate elements that might otherwise remain indistinct. The primary topic of this thesis is the utilization of the pseudo color approach, which is an image enhancement technique, to convert grayscale intensity images into color-coded images. An investigation into the various forms of pseudo color techniques that have been created in the past has been done in this work. Using the spectra returned by the Fourier transform of the input picture, the Pseudo color method applies three distinct digital filters—a high pass filter, a band pass filter, and a low pass filter—to achieve the desired effect: The Red, Green, and Blue components of the CRT electron cannons are then given the three filtered outputs that are generated, which are subsequently projected onto the screen. Therefore, a comprehensive package has been developed to execute the necessary procedures for generating the colored image. This bundle comprises two primary components. The initial one facilitates the execution of Fourier transformations and filtering operations. For the second part, a computed color table is used to mix the three components of Red, Green, and Blue to make and show the desired color. This means that each pixel in the original image will have a new value that matches the new color, which creates a new colored image. Also, Combining optimal partitioning with dynamic programming with a representation of the image for space-filling curve, we offer a novel algorithm for pseudo-coloring in this paper. The algorithm permits the fine-to-coarse assignment of triplet colors to the pixels of an image, thereby producing a pseudo-colored image that preserves either structure or detail. This is accomplished by initially considering the original gray levels in the image and then systematically decreasing them by optimal partitioning until reaching a specific number, which can include reducing the image to only two colors for a binary representation. The number of colors is output by the algorithm, and the specific allocation of colors is determined by the nature of the problem being addressed. Two sets of medical photos are used to illustrate how the algorithm is applied.

Keywords: Image Processing, Pseudo color, Medical Images, Filters

Cite as: Mohammed Rasool Jawad. (2024). Producing of High Quality Colored Images using scalable image processing techniques. *LC International Journal of STEM, 4*(4), 10–24. **https://doi.org/10.5281/zenodo.10594220**

Logical Creations Education Research Institute
LC INTERNATIONAL JOURNAL OF STEM
E-ISSN: 2708-7123
Web: www.lcjstem.com | Email: editor@lcjstem.com
Volume-04 | Issue-04 | December-2023

INTRODUCTION

When it comes to automatically colorizing photos and visualizing complex data, two-dimensional fields, and other scientific phenomena, pseudocoloring is a highly helpful technique. The user's text is empty. Pseudocoloring is mostly employed due to the human ability to perceive a vast range of color hues and intensities, in contrast to the limited number of gray level shades, which is only around two dozen (Wang et al., 2018). Numerous applications, such as tensors, vectors, and different black-and-white imaging modalities, generate numerical outputs that can be enhanced by color visualization. This paper is mostly about the second use case, where medical images can be found in black and white with a certain amount of detail (8 bits, for example, gives you 256 different gray levels).

Pseudocoloring can be applied adaptively to enhance an image, with various approaches used for high-detailed portions (considering the values in a specific neighborhood) compared to low-detailed sections. In this work, we suggest two approaches to the use of pseudo-coloring: detail-preserving and structure-preserving. By using the structure-preserving approach, an image's necessary number of gray levels is decreased along a space-filling scanning of the image applying optimal partitioning (using a certain cost function), whereas the detail-preserving method identifies change points along the scanning and colors them independently. Either approach may be utilized, contingent upon the immediate objective of the image. Pseudocanning can be understood as a mathematical one-to-three transformation of a gray level digital image f(x,y) in the following form:

$$\vec{C}(x,y) = T(f(x,y))$$

Where

$\vec{C}(x,y) = \begin{bmatrix} R(x,y) \\ G(x,y) \\ B(x,y) \end{bmatrix}$ is a color image with R, G, an B components at the $(x,y)^{th}$ spatial location (row and column respectively). $T(.) is\ a transformation function\ that\ takes$ intensity level of a pixel at (x,y) as takes an input and simultaneously generates the RGB color components at the output position. There are numerous pseudo-coloring methods available, most of them are heuristic or ad hoc in nature. Numerous methods of this kind are explained in (Aksoy et al., 2017). Pseudo-coloring can be conceptualized as a look-up table for computer implementation, as illustrated in Figure 1. The output value is represented by the R, G, and B contents at that position, while the table's index indicates the initial gray level value.

Gray-level Index →

Color LUT			
i	R-color	G-color	B-color
0	R_0	G_0	B_0
1	R_1	G_1	B_1
2	R_2	G_2	B_2
...	...	...	...
...	...	...	...
...	...	...	...
255	R_{255}	G_{255}	B_{255}

Figure 1. Pseudo-color Look-up Table

Logical Creations Education Research Institute
LC INTERNATIONAL JOURNAL OF STEM
E-ISSN: 2708-7123
Web: www.lcjstem.com | Email: editor@lcjstem.com
Volume-04 | Issue-04 | December-2023

In theory, there is the potential for an unlimited quantity of pseudo-colorings. The study includes two cases, as shown in Figure 2, which were published in references (Aksoy et al., 2017 & Mairal et al, 2007).

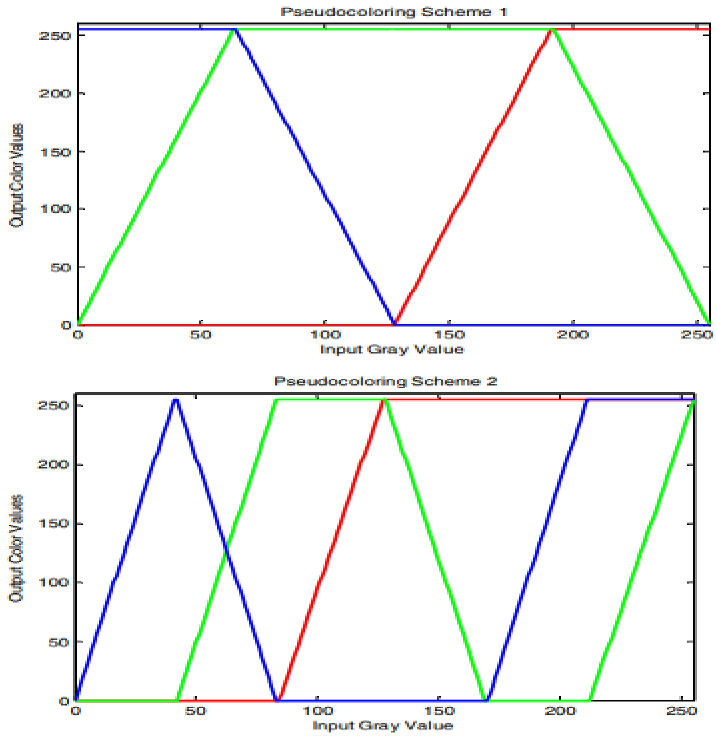

Figure 2. Two Pseudocoloring Techniques

MATERIALS AND METHODS

Pseudocolor Using Filtering Technique

The following Pseudocolor technique is based on frequency-domain operation. Figure (3) below gives an illustration to the Pseudocolor procedure used: The idea depicted in this figure is that, the image is transformed by fourier transformation operation in such a way that the Fourier transform of an image is modified independently by three filter functions. After that, the process images are then obtained by using the inverse fourier transform. This can be followed by additional processing (such as histogram equalization) before images are fed into the red, green and blue inputs of the monitor.

Logical Creations Education Research Institute
LC INTERNATIONAL JOURNAL OF STEM
E-ISSN: 2708-7123
Web: www.lcjstem.com | Email: editor@lcjstem.com
Volume-04 | Issue-04 | December-2023

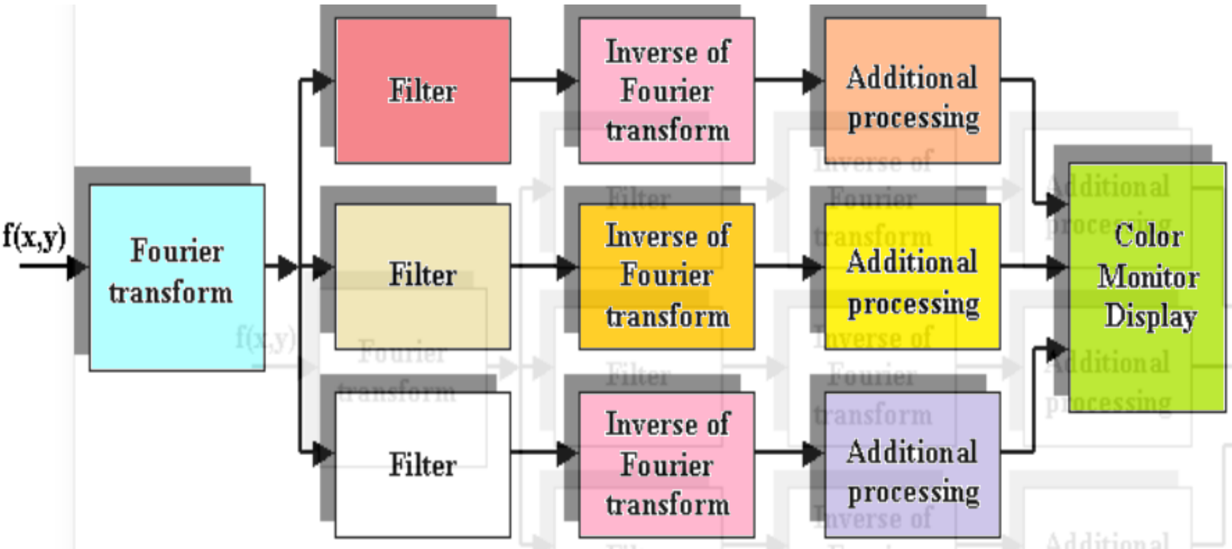

Figure 3. Pseudocolor using filtering technique

OP-based Adaptive Pseudo-coloring

We present the two adaptive pseudo-coloring techniques, which are depend on the Peano scanning, the dynamic partitioning of an interval, and the selection of a pseudo-coloring procedure (Kruse et al., 1993).

Detail-Preserving Pseudo-coloring

The detail-preserving pseudo-coloring algorithm, shown in Figure 5, is the first algorithm. Its primary objective is to locate certain locations within the image altered points that are coded separately with a various color (Red is the option that is most advised). It doesn't modify the original gray levels that are offer in the image. After Peano scans the image into a one-dimensional interval, R, and feeds this interval into the algorithm of OP, the points are discovered. Subsequently, the points provided by the OP are encoded individually, whereas the remaining points are encoded utilizing the chosen pseudo-coloring procedure. This algorithm is helpful when we want to find small details that might point out problems in the image (Nunez et al. , 1999).

Logical Creations Education Research Institute
LC INTERNATIONAL JOURNAL OF STEM
E-ISSN: 2708-7123
Web: www.lcjstem.com | Email: editor@lcjstem.com
Volume-04 | Issue-04 | December-2023

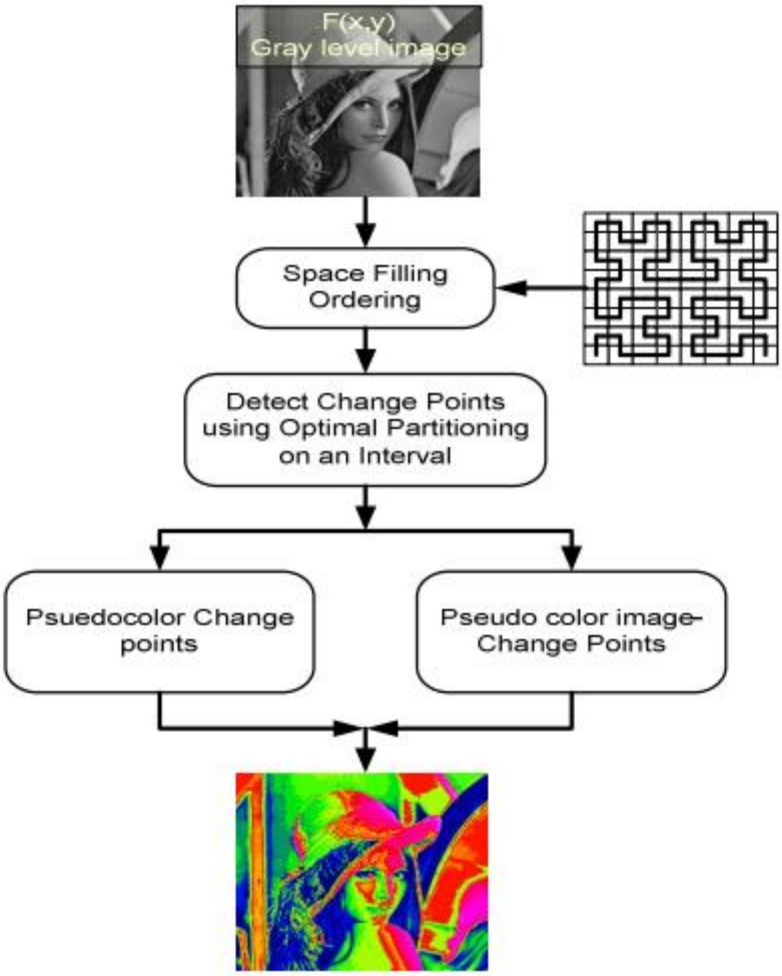

Figure 4. Detail-Preserving Pseudocoloring

Structure-Preserving Pseudo-coloring

Figure 6 depicts the structure-preserving pseudo-coloring algorithm, the 2nd of these algorithms. The primary objective is to detect prominent structures within the image. By combining several of the original gray levels into a smaller set, this is accomplished. The resulting binary form of the image can have a decreased number that ranges from the original number to just two. The quantity of reduced grayscales in the image is inversely related to the prior, a parameter used by the OP method. As the prior value goes up, the amount of gray levels goes down, and vice-versa. This algorithm is particularly valuable in situations where our attention is directed towards bones and organs in medical imaging.

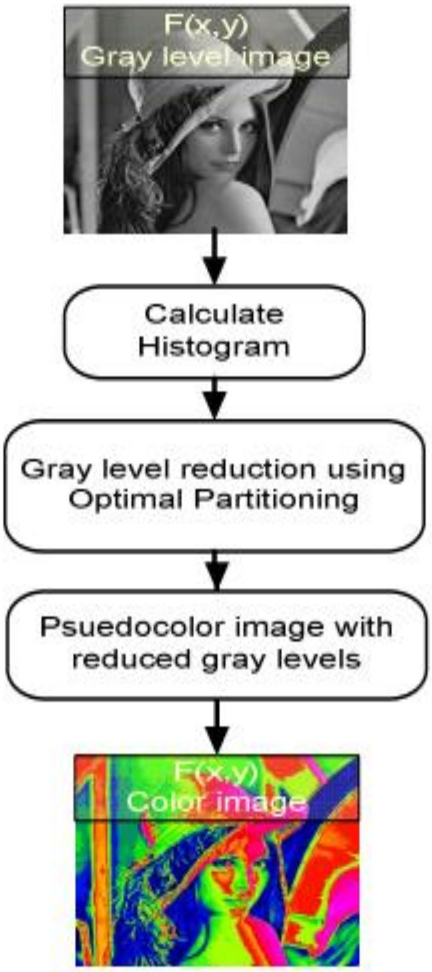

Figure 5. Structure-Preserving Pseudocoloring

RESULTS AND DISCUSSION

The "user interface" of the computer is where the user and the system interact. The designer typically conceptualizes the user interface as the combination of the terminal hardware and the software responsible for receiving, interpreting, and transmitting messages (as well as displaying them) to the user. From the perspective of the user, the definition might not be sufficient, even though it might satisfy the system designer and implementers. Any component of a computer system that the user interacts with is called the user interface. The user interface must be implemented in an interactive graphical approach that has two major aspects:-

• The first is concerned with the design of a set of library procedures for graphical input that are sufficiently general and flexible to cater for a range of possible interactive applications.

• The second aspect is concerned with using the interactive procedures to design programs that users find helpful and easy to use.

Pseudocolor program is designed to be used as a representation for the entire operations that could happen on an input image and a representation for the resulting output image (colored image) with all sub operations needed to complete and produce the result. This representation is done with an interactive way such that all the needed commands and messages are provided for the user to express the task of each visual operation displayed on the screen. The Pseudocolor program screens are designed in a way that looks similar to the screens used in the famous Microsoft Windows application program, because it provides a better graphical utilization of screen real estate, visually rich environment for conveying information and also provides the ease to control and manage the entire program. The Pseudocolor graphical interface is not only more attractive in appearance, but it also imparts a high level of information to the user. Within this graphical user interface, the video display assumes the role of a user input source. The video display displays a variety of graphical items, including buttons, scroll bars, and other input devices in the form of icons. A user can directly manipulate these on-screen items using a pointing device like a mouse or, more specifically, a keyboard. It is possible to drag and drop graphic items, push buttons, and scroll scroll bars. The user-program interaction thus gets more intimate. Users can try out new options and learn more about the program's features by using the choices and dialog boxes. It is simple for a user to navigate between menus and transfer data between them.

The graphics system used supports many different input devices, and the graphics library provides a means of controlling these in as a uniform manner as possible. One of these devices is the mouse which is a relatively recent and potentially powerful Pointing device that represent a natural and best suited way to interact with a graphics environment. Several mouse interfacing functions are developed to perform different functions such as initializing the mouse, determining the status and position of the mouse, controlling the movement within a program and finally detecting the presses of any button. The functions is given in more detail below:
(1)- Init Mouse:- This function is used to check if the mouse device and device driver are installed and if so, to put the cursor at the top left of the screen and turn it on. (2)- Show Mouse:- This function is used to turn the mouse cursor on. (3)- Hide Mouse:- This function is used to remove the mouse cursor from the screen. (4)- Get Mouse Coordinate:- This function is built up to return the mouse coordinates (X-mouse, Y-mouse) on the screen. (5)- Get Button Pressed:- This function returns the status of the mouse button; Zero = no button pressed, One = left button is pressed, Two = right button is pressed

The Pseudocolor program design uses two main graphical screens. The first one is based on the use of the PASCAL language graphics utility that provide the user with a 640 X 480 screen resolution and with 16 colors in the palette lookup table. This screen provides most of the graphical library procedures (or functions) needed to design and implement the screen. The second graphical screen is based on the use of the interrupt commands provided by the BIOS (Basic Input Output System) of the computer that supports a 320 X 200 screen resolution with 256 colors in the palette lookup table so as to draw the colored resultant images and the other needed visual operations. The general outline of the Pseudocolor program design can be given in the following diagram that shows the connection between the various parts of this design with each other and with the mouse input device:-

At the top of the first graphical screen, there is a menu bar consisting a line of menu titles that are: File, Filter's parameter, Help and Exit options. At the bottom of this screen there is a small dialog box used to record and display the appropriate messages to the user when an action is performed, and also to give helpful information so that the user is not mislead. The four options in the main menu can be accessed during any stage of the running of the program and can be chosen by pressing the left mouse button. If we go back to the first pop up menu, the other option (CANCEL) is used to remove the file pop up menu and returns the action to the main menu again. Figure (4) below shows the main menu design with the file pop up menus mentioned above:

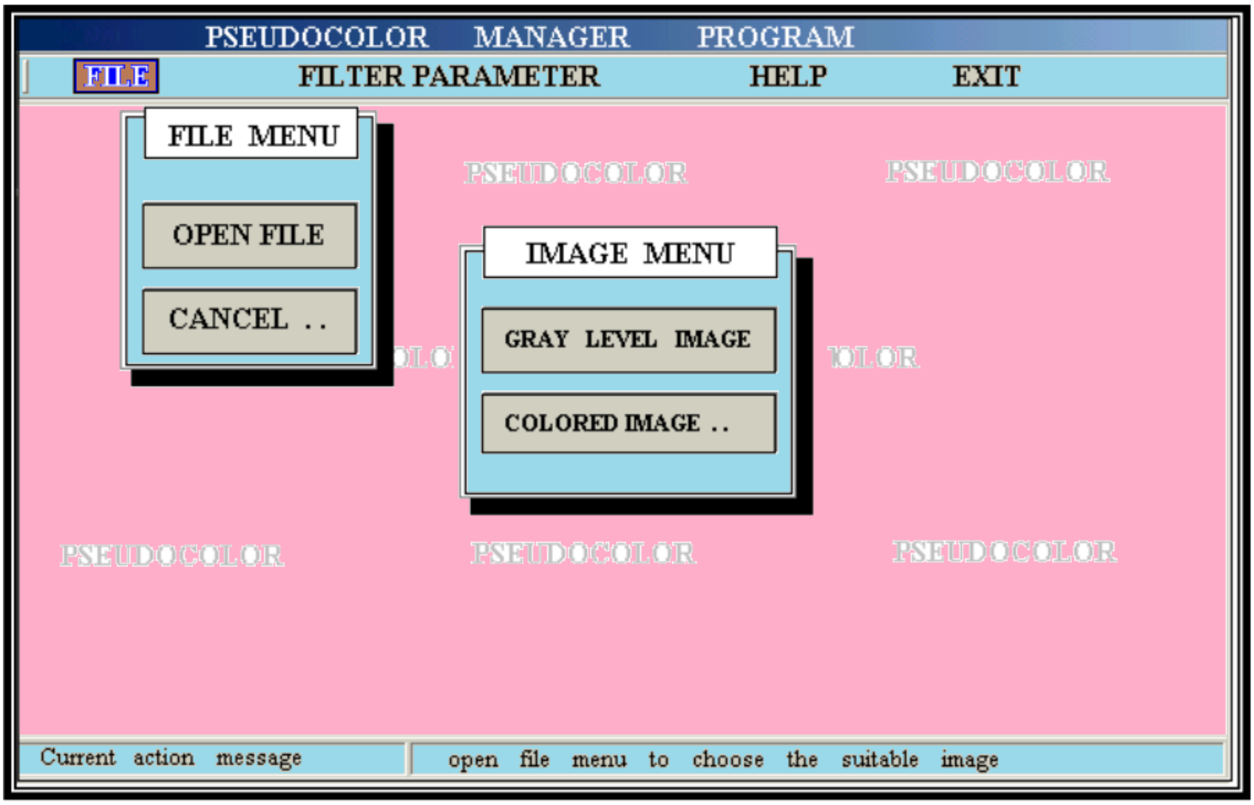

Figure 6. The main menu options with the pop up menus

The open window mentioned above consists of four small rectangle view port and these are : i- The file name view port :- This small area is used to record the name of the image chosen. ii- The files listing view port :- This area is used to display all the names of the images under the working directory that have the extensions limited by the image type view port described below.

iii- The image display view port :- This area is used to display the image of the chosen name to be seen before going on with any further processing operations. iv- The image file type view port :- A rectangle is displayed to record file extensions that could be used in this program. The default extensions used are (*.IMG for gray color images and *.COL for colored images).

Logical Creations Education Research Institute
LC INTERNATIONAL JOURNAL OF STEM
E-ISSN: 2708-7123
Web: www.lcjstem.com | Email: editor@lcjstem.com
Volume-04 | Issue-04 | December-2023

The following figure (4) shows this open window with all the details mentioned.

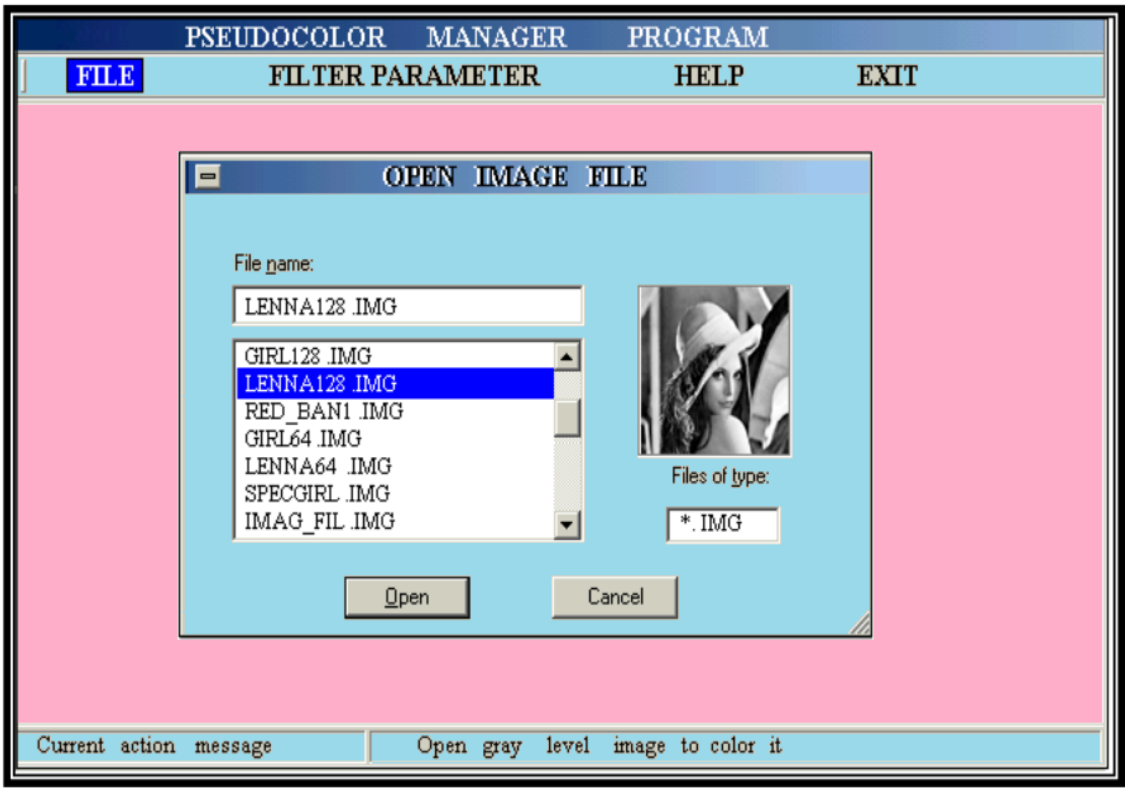

Figure 7. Open window with its options

When an image is chosen and the Fast Fourier operation is carried out on this image, another important operation is needed to be performed which is the filtering operation. Each one of the red, green and blue filters mentioned in the last chapter needs a parameter that determines the distance from a point (u,v) to the origin of the frequency plane of the Fourier spectrum, so that to limit the frequency band that must be processed (Allayla, . When activating this option a small pop up menu with three options is displayed on the screen, these options can be listed below:

The red filter is used to pass all the high frequency values and attenuate all the others, thus it needs a threshold parameter to decide the range of values that passes from the origin to the point determined by the threshold parameter. So, when choosing this option, a small rectangle is displayed with a message asking the user to enter a threshold value within a range of values given inside this small box. (2)- Green filter parameter option:- The green filter is used to pass a range of frequencies between two threshold parameter values. This option needs to enter these two parameter values. When choosing this option another box is displayed asking to enter these threshold values. (3)- Blue filter parameter option:- The blue filter is used to attenuate the high frequency values and pass the low ones, thus it needs a parameter to decide the range of these high frequencies to attenuate them and passes all the others. When choosing this option the same process of displaying box and message that asks the user to enter the threshold value as with red and green options. The filters parameter option is disabled during the running of the

Logical Creations Education Research Institute
LC INTERNATIONAL JOURNAL OF STEM
E-ISSN: 2708-7123
Web: www.lcjstem.com | Email: editor@lcjstem.com
Volume-04 | Issue-04 | December-2023

program until reaching the filtering operation stage. The figure of this option is given within the other figures concerning the other sub-menus of the filtering operations that will be discussed later.
Any useful information that could help the user is provided within this option. This option is enabled during any operation within the program to display and describe the task of the current operation in detail and to describe the possible output that could be produced form this operation. When activating this option, a small window is displayed with three graphical button options, that are:

(1)- PAGE DOWN (PG/DN) option:- This option is used to scroll down the help screen so as to display further information concerning the current operations performed (Al_Mukhtar F. H., 1997).
(2)- PAGE UP (PG/UP) option:- This option is used to scroll up the help screen so as to display the previous information already displayed before.
(3)- CANCEL option:- This option is used to remove the help screen and returns the action to the main menu.
When choosing this option, a small window appear on the middle of the screen displaying a message for confirmation. This window provides two graphical button options (Yes, No). When the first option (Yes) is choosed, the execution of the Pseudocolor program is then terminated and the system is then returned to the DOS command line waiting for the user to enter any DOS command. If the user chose the option (No), then the exit window is removed and control is returned to the main menu (Al_Mukhtar F. H., 1997).

The Other Sub-Menus Design;- When the open image window mentioned above is displayed on the screen and a gray level image is selected, Fast Fourier transform and the filtering operations are performed. Starting with the Fast Fourier transform operation, a new screen is displayed to the user with one option called (Fourier Transform). With this option, we can choose either (Help or Exit) from the main menu. Choosing Fourier Transform option causes the Pseudocolor program to perform the Fast fourier operation on the selected image. Figure(4) shows the Fast Fourier transform window :

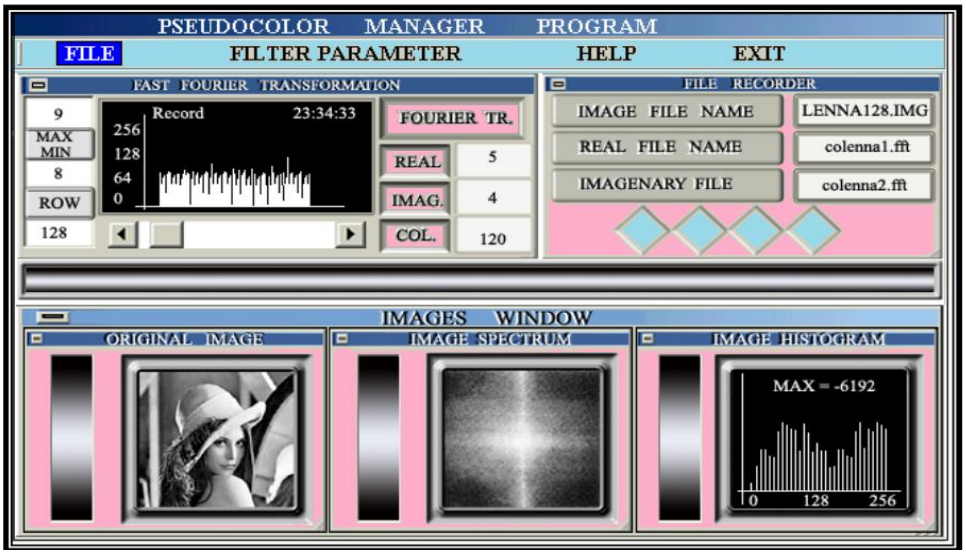

Figure 8. Fourier transform graphical display windows

Logical Creations Education Research Institute
LC INTERNATIONAL JOURNAL OF STEM
E-ISSN: 2708-7123
Web: www.lcjstem.com | Email: editor@lcjstem.com
Volume-04 | Issue-04 | December-2023

The objects and forms found in this figure are :

1- Two small rectangles to record the rows and the columns of the selected image that have been processed thus far.
2- A rectangle to record the histogram of each row of the image processed by the fourier transform.
3- A small box to record the maximum frequency value in the produced spectrum.
4- An image of the spectrum produced.
5- A histogram of the original image.
6- A window used to record the file name that have been used to perform the Fast Fourier transform operation.

After finishing the Fast Fourier transformation operation, the screen is then changed to another one for performing the filtering operation (Al_Mukhtar F. H., 1997). This new screen is displayed with four graphical options (Complete filtering, Red filtering, Green filtering And Blue Filtering) and with three of the main menu options Filter's parameter, Help and Exit). Figure 9 below shows this new screen with all options mentioned :

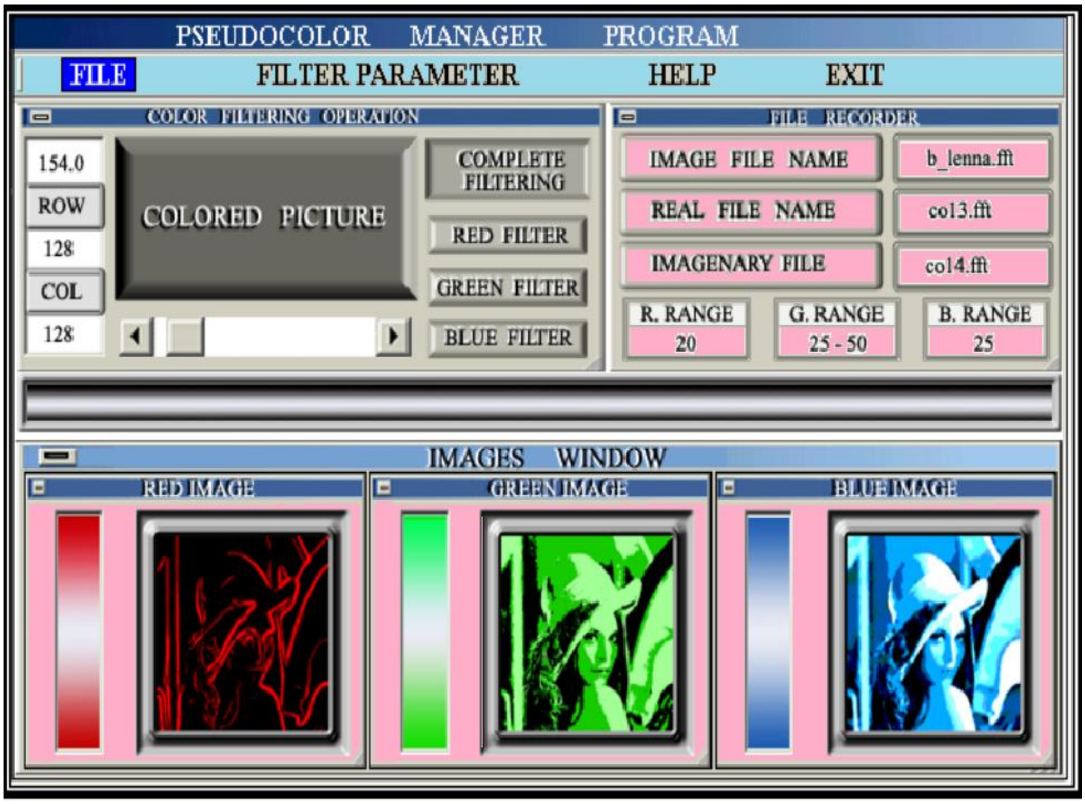

Figure 9. Filtering operation graphical display windows

Through algorithmic effectiveness testing, we have achieved good results across a range of medical image types. As a result of limited space, we are only able to display a small selection of coded images, each with a narrow range of gray levels. A journal version that has been submitted will provide more information. Together with the original image on the left, Figures 10 and 11 display the findings for the detail and structure maintained algorithms, respectively. The version that was carefully preserved

Logical Creations Education Research Institute
LC INTERNATIONAL JOURNAL OF STEM
E-ISSN: 2708-7123
Web: www.lcjstem.com | Email: editor@lcjstem.com
Volume-04 | Issue-04 | December-2023

highlighted all the change sites by coding them with a pure red hue. This allowed OP to easily identify them. In contrast, the structure-preserving approach in the provided examples decreased the initial range of gray levels (255) to 32. By supplying a Prior value that indicates our confidence in the overall degree of structure present in the image, the number 32 is implicitly indicated. The previous serves as a deterrent to the image's quantity of thresholds. Although it is challenging to put a number on the amount of output gray levels in relation to the prior, we can say with certainty that a higher value will result in fewer areas since the algorithm will ignore less important structures in the image. Notably, our approach is compatible with every other pseudo-coloring algorithm now in use. Adding an additional layer of interaction to the image based on the viewer's objective is all that it does. In order to highlight key structures, including organs and bones, the structure preserving method might be placed in between the pseudo-coloring process and the image. On the other hand, if we want to focus on the details, the detail-preserving method marks the important change points in any color the viewer wants after the pseudocoloring is already done (Jinxiu et al., 2007).

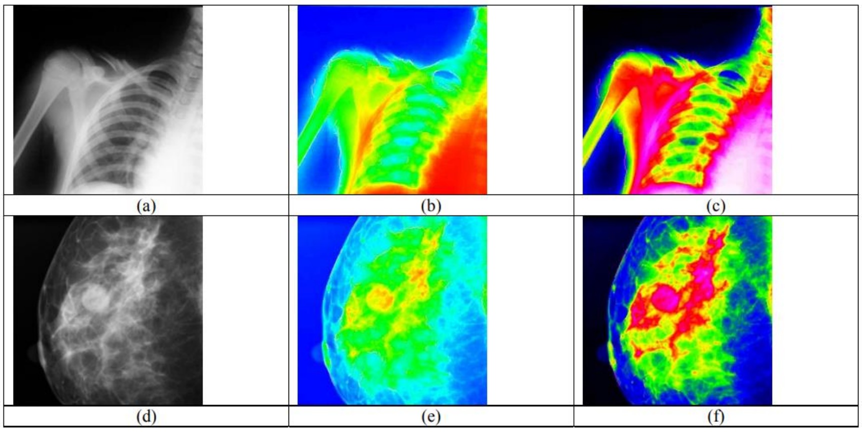

Figure 10. Detail-Preserving Pseudocoloring Results

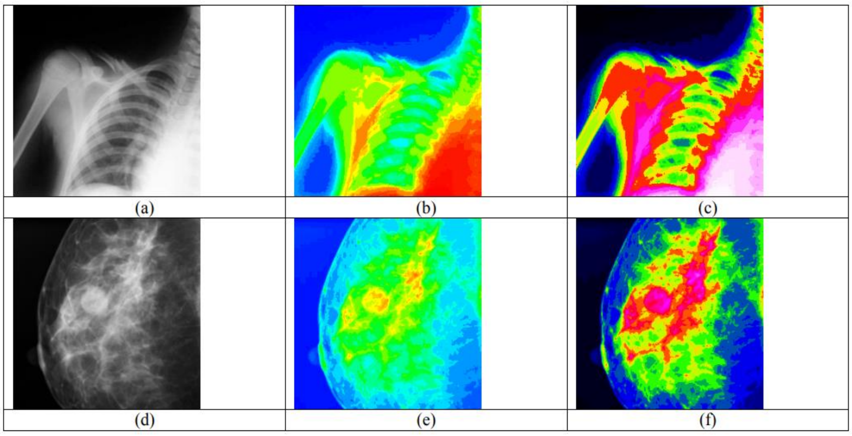

Figure 11. Preservation of Structure via 32 Gray Levels of Pseudo-coloring

Logical Creations Education Research Institute
LC INTERNATIONAL JOURNAL OF STEM
E-ISSN: 2708-7123
Web: www.lcjstem.com | Email: editor@lcjstem.com
Volume-04 | Issue-04 | December-2023

CONCLUSION AND RECOMMENDATIONS

This study introduces novel adaptive techniques for Pseudo-coloring gray level images. The algorithms combine the clustering features of space-filling curves with dynamic partitioning on an interval. By removing any unnecessary gray levels from the image, the algorithms enable the viewer to either concentrate on the main structures or highlight specific details with additional processing. The optimal partitioning method enables the utilization of a suitable cost function and allows for control over the number of output gray levels. This control is achieved by a prior constraint on the number of classes contained in the image. The method is capable of creating various numbers of gray levels, including two gray levels for binary images. The detail preserving approach uses the space filling curves' clustering property to incorporate spatial information in the image. Future studies will look into additional techniques, such as entropy, to incorporate geographical information; additionally, we will systematically address some of the outstanding concerns, such as the algorithm's speed and quantifying the prior parameter, in order to reach a set number of thresholds. Also, from the above outcome, we realized that the RGB system has several weaknesses that need to be overcome. Thus, another system that can replace the RGB system and fulfills the user needs by providing the user with a tool to change the color according to human expectation is the HIS system (Hue, Intensity and Saturation). The aim of this system is to easily get colors wanted by users and no attention is paid to color difference. To convert from RGB system to HIS system, a - mathematical expressions are necessary in which calculated color differences fulfills all user needs. The color produced is converted back to RGB color system to be assigned to the RGB CRT electron guns.

REFERENCES

Edwards, A. A., Steacy, L. M., Siegelman, N., Rigobon, V. M., Kearns, D. M., Rueckl, J. G., & Wang, T. C., Liu, M. Y., Zhu, J. Y., Tao, A., Kautz, J., & Catanzaro, B. (2018). High-resolution image synthesis and semantic manipulation with conditional gans. In *Proceedings of the IEEE conference on computer vision and pattern recognition* (pp. 8798-8807).

Aksoy, Y., Aydin, T. O., Smolić, A., & Pollefeys, M. (2017). Unmixing-based soft color segmentation for image manipulation. *ACM Transactions on Graphics (TOG)*, *36*(2), 1-19.

Mairal, J., Elad, M., & Sapiro, G. (2007). Sparse representation for color image restoration. *IEEE Transactions on image processing*, *17*(1), 53-69.

Kruse, F. A., Lefkoff, A. B., Boardman, J. W., Heidebrecht, K. B., Shapiro, A. T., Barloon, P. J., & Goetz, A. F. H. (1993). The spectral image processing system (SIPS)—interactive visualization and analysis of imaging spectrometer data. *Remote sensing of environment*, *44*(2-3), 145-163.

Nunez, J., Otazu, X., Fors, O., Prades, A., Pala, V., & Arbiol, R. (1999). Multiresolution-based image fusion with additive wavelet decomposition. *IEEE Transactions on Geoscience and Remote sensing*, *37*(3), 1204-1211.

Foi, A., Katkovnik, V., & Egiazarian, K. (2007). Pointwise shape-adaptive DCT for high-quality denoising and deblocking of grayscale and color images. *IEEE transactions on image processing*, *16*(5), 1395-1411.

M Allayla, N., Nazar Ibraheem, F., & Adnan Jaleel, R. (2022). Enabling image optimisation and artificial intelligence technologies for better Internet of Things framework to predict COVID. *IET Networks*.

Al_Mukhtar F. H. (1997).Psedocolor Implementation Of Gray Level Images, A Thesis Submittad to the College of Science of Al-Nahrain University in Partial, Filfilment of the requirements For The degree of Master of Science In Computer Science.

Tongying, L. I., & Hongbo, Z. H. U. (2020, August). Research on Color Algorithm of Gray Image Based on a Color Channel. In *2020 Chinese Control And Decision Conference (CCDC)* (pp. 3747-3752). IEEE.

Gao, H., Zeng, W., & Chen, J. (2019). An improved gray-scale transformation method for pseudo-color image enhancement. Компьютерная оптика, 43(1), 78-82.

Zabala-Travers, S., Choi, M., Cheng, W. C., & Badano, A. (2015). Effect of color visualization and display hardware on the visual assessment of pseudocolor medical images. *Medical physics*, *42*(6Part1), 2942-2954.

Ning, C. Y., & Liu, S. F. (2013). Enhancement Algorithm Combining Pseudocolor Processing and Marker-based Watershed Transform for Medical Image. *Advanced Materials Research*, *655*, 1953-1956.

Jinxiu, L., Junli, L., & Ping, W. (2007, July). Pseudocolor coding of medical images based on gradient. In *2007 1st International Conference on Bioinformatics and Biomedical Engineering* (pp. 932-935). IEEE.

Comess, K. A., Beach, K. W., Hatsukami, T., Strandness Jr, D. E., & Daniel, W. (1992). Pseudocolor displays in B-mode imaging applied to echocardiography and vascular imaging: an update. *Journal of the American Society of Echocardiography*, *5*(1), 13-32.

Prashant, G. P., & Jagdale, S. M. (2017, October). Information fusion for images on FPGA: Pixel level with pseudo color. In *2017 1st International Conference on Intelligent Systems and Information Management (ICISIM)* (pp. 185-188). IEEE.

Logical Creations Education Research Institute
LC INTERNATIONAL JOURNAL OF STEM
E-ISSN: 2708-7123
Web: www.lcjstem.com | Email: editor@lcjstem.com
Volume-04 | Issue-04 | December-2023

AUTHORS PROFILE

The author holds a technical diploma in communications and a bachelor's degree in computer science. Master's degree in Networking and Information Systems. He currently works in the Ministry of Higher Education and Scientific Research in Iraq as a computer professor. He has published 3 research papers in reputed international journals including Thomson Reuters (SCI & WEB of Science) and conferences including IEEE which are also available online. His main research work focuses on Network Algorithms, Big data analytics, Data mining, Computational Internet of Things, and Computational Intelligence-Based Education. He has 10 years of teaching experience and 5 years of research experience.