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Image Stylization Through Spatial Filtering

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***Abstract:** In this research, we offer an algorithm that automatically creates pencil sketches and watercolor (with and without canvas) drawings from user-provided photographs. The main attraction of this algorithm is that it is created from scratch using very basic image processing techniques only without using any complicated functions.*

***Keywords:** Pencil Sketch; Watercolor; Image Processing; Gaussian Blurring; Bilateral filter*

I. INTRODUCTION

In computer science, digital image processing has evolved as a significant field with applications in a variety of industries, including automation, medical imaging, and creative arts [1][12][13]. This study focuses on a specific application of digital image processing: converting real-life images into creative interpretations with Python.

The fundamental principle of digital image processing is the manipulation of pixel data to generate various visual effects or extract specific information. This modification is classified into numerous forms, including image enhancement, restoration, compression, and synthesis. In this study, we investigate the artistic alteration of images, utilizing techniques such as spatial filtering, which is essential to many image processing applications.

Spatial filtering [2][14] is a crucial step used in digital image processing that involves modifying an image by changing its pixels [3]. To generate different artistic effects, blurring, sharpening, edge detection, noise reduction, etc. techniques are used. In this study, spatial filtering is used to produce effects similar to traditional art forms such as sketches and watercolor paintings. For this purpose, Gaussian blurring is used, which is a crucial technique that smoothes a picture by averaging pixel values with their neighbors, weighted by a Gaussian function, resulting in less noise and detail and giving a softer, painted appearance [4-5][16]. A non-linear filter called a bilateral filter [6-7][15] is also employed to smooth out any image while maintaining all of its edges.

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We can mathematically define this filter as:

$$I^{filtered}(x) = \frac{1}{W_p}\sum_{x_i \in \Omega} I(x_i)\, f_r(||\,I(x_i) - I(x)||) \times g_s(||\,x_i - x||) \qquad \text{.......... (1)}$$

Here W_p is the normalization factor defined as

$$W_p = \sum_{x_i \in \Omega} f_r(||\,I(x_i) - I(x)||)\, g_s(||\,x_i - x||) \qquad \text{.......... (2)}$$

and $I^{filtered}$ is the filtered image; I is the original image; x is the coordinates of the pixel to be filtered; Ω is the window centered in x; $x_i \in \Omega$ indicates another pixel; f_r is the range kernel for smoothing differences in intensities; g_s is the spatial kernel for smoothing differences in coordinates.

This project exemplifies the convergence of computer science and art by demonstrating how digital image processing can result in new forms of artistic expression. By knowing and implementing basic spatial filtering techniques and convolution operations and using Python's rich libraries, this study drives both creative and technological advances in digital art and elsewhere.

II. NEED FOR THE STUDY

The convergence of technology and art has transformed how we approach artistic expression, notably through digital image processing. This study fills a significant vacuum in the field by creating ways to convert real-world pictures into creative representations from scratch. Unlike other approaches that rely primarily on complicated, pre-existing algorithms, our study focuses on creating digital art effects with basic techniques like spatial filtering, Gaussian blurring, etc. These methods are not only fundamental to the industry but also widely available, allowing for a more intuitive exploration of digital artwork.

This work is motivated by a goal to democratize digital art creation. In an era when digital tools are becoming more complex and widely used, there is an urgent need for approaches that are both sturdy and user-friendly. By focusing on fundamental image processing techniques, we enable artists, designers, and hobbyists to experiment with and create high-quality digital artworks. The study's innovative approach at the basic level ensures that even persons with low technical knowledge can connect with and contribute to the digital art community. This research is significant not only for its technological achievements but also for promoting the fusion of classic art forms with contemporary digital practices. By bridging the gap between the two worlds, we not only broaden the possibilities of the digital medium but also honor and reinterpret traditional artistic techniques in a contemporary context. This confluence of art and technology is critical for driving innovations and broadening the boundaries of what is possible in digital art. This work serves as a foundation for future research, providing new tools and insights into both computer science and the arts.

III. PROCEDURE

As mentioned earlier, we created the sketching effect and the watercolor effect (with and without canvas) completely from scratch without using any pre-defined or complicated functions. This indicates that we can easily create multiple paint effects on real-life images, mainly by convoluting the given image with various types of kernels and filters using Python.

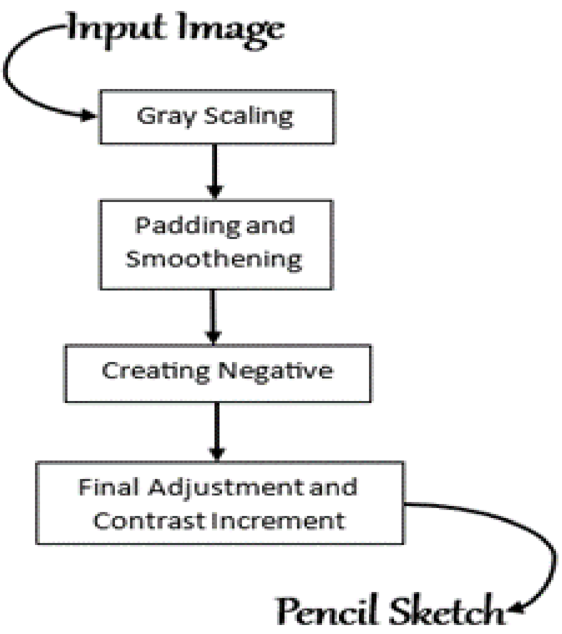
Convolution [8] is a mathematical operation that combines two image functions, f, and g, to create a third function, f★g, which shows how the form of one function is changed by the other. In the case of a linear spatial filter, the sum of products operation merges an image f with a filter kernel w. For a kernel of size mn, the convolution on the image f(x,y) is defined as follows:

$$(w * f)(x, y) = \sum_{s=-a}^{a} \sum_{t=-b}^{b} w(s,t) f(x-s, y-t) \quad \text{..... (3)}$$

where a and b can be selected accordingly. Like for 3×3 kernel a=b=2.

A. Pencil Sketch Effect

The necessary steps to create the pencil sketch effect are shown in the figure given below.



Description: As indicated in the figure, after reading the input image, we converted the image from RGB to grayscale and inverted that grayscale image to get a negative. Then we padded the inverted image with zeros and convolved that padded image multiple times with a 2-D Gaussian kernel [6][9] defined as:

$$w(s,t) = \frac{1}{\sqrt{2\pi\sigma^2}} e^{-\frac{s^2+t^2}{2\sigma^2}} \quad \text{....... (4)}$$

where σ defines the width of the Gaussian kernel and s and t are horizontal and vertical distances from the origin in the kernel's domain respectively. This convolution is called Gaussian smoothing, and we used a 3X3 Gaussian kernel here.

After completing the necessary smoothing, we divide the original grayscale image with this smoothed inverted image and increase the contrast of the resultant image. This gives the final pencil sketch of the primary colored image.

B. Watercolor Art

For the watercolor effect, after reading the input color image, we extracted the blue, green, and red color channels and padded each color channel with zeros. Then, just as before, we employ several 2-D Gaussian smoothings here, but in this case, 3X3 and 5X5 both Gaussian kernels were needed in contrast to the previous use of only one kind. We merged all three smoothed RGB color channel images together and saved that image inside a variable (Let X). Now, we convolved that image multiple times with a bilateral filter [5][8] to enhance the image by maintaining the edges while reducing noise and smoothing out the image. We weighted the resultant image with a factor of 1.5. We also weighted "X" with a factor of -0.5 and added both weighted images together to get the final watercolor art of the initial colored image.

Now, to give a 'watercolor on canvas' effect, we have chosen the canvas texture and changed the canvas size so that it can contain the entire watercolor image we created earlier. Now we give that watercolor a weight of 1.2 and the canvas a weight of - 0.4 and add these weighted images together to get the final 'watercolor on canvas' effect. The entire process is graphically described in Fig. 1.

IV. RESULTS

This work aimed to create an effective code to create good artistic effects on any image without using any type of complicated functions or pre-defined modules. The outputs are shown in the figures given below. Fig 2: (a), (d), and (g) are the input images, and Fig 2: (b), (e), and (h) show the resultant pencil sketch effect, respectively. Similarly, Fig 2: (c), (f), and (i) show the resultant watercolor effect. Now, to get the watercolor in canvas effect, we have used the canvas shown in Fig 3, and the final output for the same input images is shown in Fig 4.

V. CONCLUSION

This paper describes a method to create a pencil sketch effect, watercolor painting (within or without canvas) automatically from photos using very basic and simple image-processing techniques. This easy and user-friendly algorithm will motivate readers to create effective algorithms using basic image processing to generate more artistically complicated effects efficiently.

VI. ACKNOWLEDGEMENT

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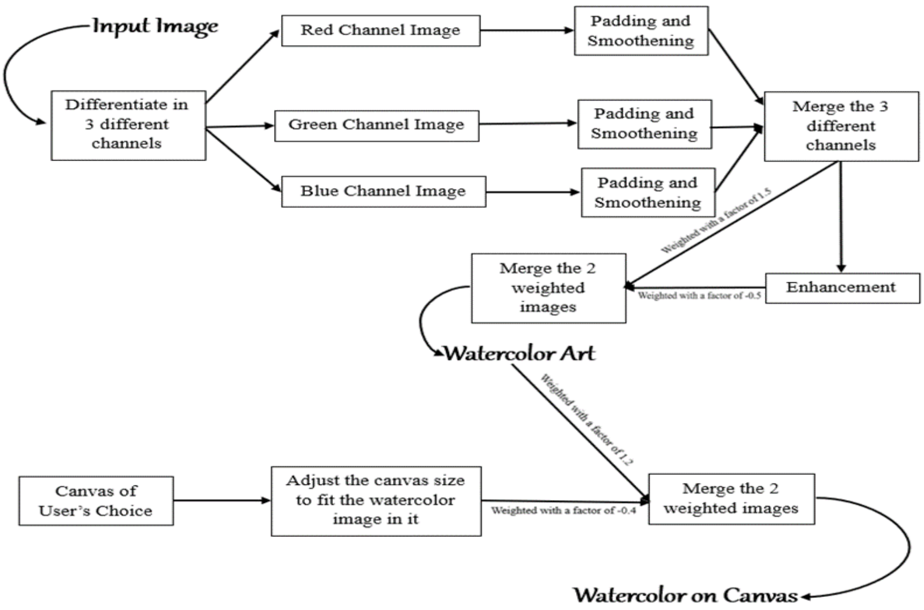

Fig. 1: Outlines of The Steps to Create a Watercolor Effect (With and Without Canvas)

Fig 2: (A) Original Image

Fig 2: (B) Pencil Sketch

Fig 2: (C) Watercolor Effect

Fig 2: (D) Original Image

Fig 2: (E) Pencil Sketch

Fig 2: (F) Watercolor Effect

Fig 2: (G) Original Image

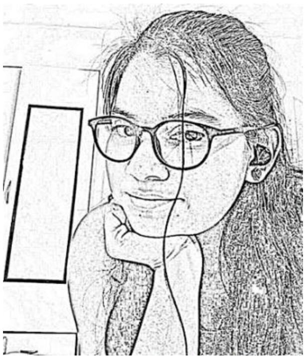

Fig 2: (H) Pencil Sketch

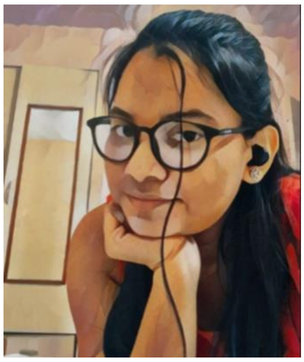

Fig 2: (I) Watercolor Effect

Fig 3: Used Canvas

Fig 4: Watercolor on Canvas

DECLARATION STATEMENT

After aggregating input from all authors, I must verify the accuracy of the following information as the article's author.

- **Conflicts of Interest/Competing Interests:** Based on my understanding, this article has no conflicts of interest.
- **Funding Support:** This article has not been sponsored or funded by any organization or agency. The independence of this research is a crucial factor in affirming its impartiality, as it has been conducted without any external sway.
- **Ethical Approval and Consent to Participate:** The data provided in this article is exempt from the requirement for ethical approval or participant consent.
- **Data Access Statement and Material Availability:** The adequate resources of this article are publicly accessible.
- **Authors Contributions:** Each author has individually contributed to the article. First two authors are the project students who have executed the project and third author is the project guide.

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