IMAGE PROCESSING

Linear Algebra & Vector Geometry

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Abstract.

Image processing involves manipulating and enhancing digital images using algorithms and techniques. One common technique is image blurring, which is used to smooth out noise and reduce detail in an image. This can be achieved through various methods, such as convolving the image with a kernel determined by a Gaussian function or using a box filter to apply uniform blurring. Image blurring is often used to improve the aesthetic quality of an image or to prepare it for further processing.

In this project will build up a piece of software that is capable of computing and displaying a blurred image given a source image. We will implement it mainly using Python and some mainstream libraries. Namely, **NumPy, OpenCV** for the actual code, and **Kivy** for the **UI**.

Background.

There are many blurring algorithms. Most popular ones are
1- Bilateral Blurring.
2- Gaussian Blurring.
3- Median Blurring.

One benefit of **Gaussian blurring** over bilateral blurring is that it is faster to compute. **Bilateral blurring is a more computationally intensive** technique that uses both spatial and intensity information to preserve edges in the image while smoothing. This makes it more effective at preserving edge detail, but it can be slow to compute.

Median blurring works by replacing the value of each pixel with the median value of the pixels in a neighborhood around it. One benefit of median blurring is that it is more effective at **preserving sharp edges in the image**, as it replaces pixel values with the median rather than the mean, which can be more sensitive to outliers.

Since speed is a concern, then Gaussian blurring is our best bet.

Introduction.

Linear algebra is used in the implementation of Gaussian blurring because the convolution operation that is used to apply the kernel to the image is a linear operation. Convolution involves multiplying the kernel values by the pixel values in the image and summing the results to obtain the new pixel value for the output image. This operation can be represented using matrix multiplication, which is a fundamental operation in linear algebra.

Gaussian blurring is a common image processing technique used to smooth out noise and reduce detail in an image. It works by convolving the image with a small matrix of weights, known as a kernel, which is determined by a Gaussian function. This function gives higher weights to pixels that are closer to the center of the kernel and lower weights to pixels further away. The resulting effect is that the image appears smoother and less noisy. Gaussian blurring is often used to reduce the appearance of noise in images, as well as to make the image look smoother overall by reducing the level of detail. It can also be used to slightly blur an image in order to reduce the visibility of blemishes or other imperfections.

To give a sense of how Gaussian blurring works, it is useful to understand how images are represented in a computer. **An image is essentially a matrix of pixel values, where each pixel value represents the color of that pixel**. In a grayscale image, each pixel value is a single number representing the intensity of the pixel, with higher values corresponding to lighter shades and lower values corresponding to darker shades. In a color image, each pixel value is a tuple of three numbers representing the red, green, and blue (RGB) values of the pixel.

The Gaussian kernel is created using a Gaussian function, which is a continuous, symmetric function with a bell-shaped curve. The shape of the curve determines the degree of blurring that will be applied to the image. The standard deviation of the Gaussian function controls the width of the curve and therefore the amount of blurring that will be applied.

Methodology.

The blurring function works as follows

$$G(x, y) = \frac{1}{2\pi\sigma^2} e^{-\frac{x^2+y^2}{2\sigma^2}}$$

Where (x) is the rows number, (y) is the column number, and (σ) is the kernel number*.

***kernel is a matrix of weights** that is used to convolve with the image. The size of the kernel is usually represented as a width and height (e.g., 3x3, 5x5, etc.). For the kernel to be effective at smoothing the image, it should have an odd size, with the center pixel representing the pixel being smoothed.

Having an odd-sized kernel ensures that there is a center pixel that can be used as the reference point for the smoothing operation. If the kernel had an even size, there would not be a single center pixel, and it would be more difficult to determine how to apply the smoothing.

larger the sigma the broader the gaussian, it is not important how broad the gaussian is as it always normalizes to two pi sigma squared, kernel size K = 2 pi sigma.

Conclusion.

In conclusion, image blurring is an important technique in image processing that is used to smooth out noise and reduce detail in an image. **Gaussian blurring** is a popular method of achieving this, as it uses a kernel determined by a Gaussian function to **give higher weights to pixels closer to the center and lower weights to pixels further away**. This results in an image that appears smoother and less noisy. Image blurring is widely used in a variety of applications, including improving the aesthetic quality of images and preparing images for further processing. Overall, Gaussian blurring is a powerful and effective tool for achieving image blurring.

References.

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2- Devi, M., & sushma, G. S. naga. (n.d.). Linear algebra in image processing. JETIR. Retrieved January 7, 2023, from https://www.jetir.org/view?paper=JETIR2204008