

Evaluation of Different Kernels for Spatial Filtering Techniques Under Image Processing

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Abstract

Background: Digital Image Processing is one of the most emerging techniques that are widely expanding and evolving. It is a process of converting an image into a digital format and performing various operations on it, such as enhancing the image or extracting valuable features out of it.

Objectives: The main motive of image processing and analysis is to use kernels for sharpening and smoothing of a digital image for getting better results.

Methods: A filter can be characterized as a kernel, which can be defined as a small array applied to every pixel and on their adjacent neighbours in the given image. The image filtering algorithm provides us with smoothness and better resolution from the noisy version. Here, in this paper we have briefly explained about the image filtering.

Statistical Analysis: Digital image processing in this paper is done by using open cv with the help of python language and jupyter notebook is used as a tool to evaluate the whole process.

Findings: Image filtering is a technique for altering the size, shape, colour, depth, smoothness, and other image properties. The final outcomes that are shown here include processed images as sharpened images, smooth images, edge detected images etc.

Applications: Image filtering is one of the fascinating applications of image processing. Filtering is a versatile method that is used in many ways and in a wide range of engineering and scientific problems, including signal processing, electronics, physics, chemistry, and image analysis/processing.

Improvements: In future the same work can be carried forward and can be applied in different domains to get processed images and used for further research work.

Keywords: Sharpening, Smoothing, Kernel, Filtering.

1. Introduction

The conversion of an image into a digital format uses a series of operations and the process to extract relevant data out of it is known as image processing. The fundamental steps in image processing include image acquisition, enhancement, restoration, colour processing, wavelets and multi-resolution processing, compression, morphological processing, segmentation, representation and description, and recognition. Image acquisition is the first step, followed by enhancement to highlight features of interest. Restoration uses mathematical or probabilistic models to improve image appearance. Colour processing includes various techniques for digital colour modelling. Wavelets are used for data compression and pyramidal representation. Compression reduces storage or bandwidth requirements. Morphological processing morphs images based on their shapes. Segmentation partitions images into constituent parts or objects. Representation and description prepare segmented regions for further computer processing. Recognition assigns labels to objects based on their descriptions. In image processing, filters are

used for sharpening and smoothing such as- Spatial filtering, when implementing the Spatial Filtering technique on an image, a mask is typically applied with a specific centre pixel [2], and it is often resized for optimal usage. The mask is then shifted across all pixels in the image so that the centre of the mask covers each pixel in turn.

There are two types of spatial filtering:

- **Smoothing Spatial Filter:** The Smoothing Spatial Filter is a useful tool in image editing that helps to blur and reduce noise [1]. Blurring [3] is applied to eliminate small details, while noise reduction is achieved through blurring. It is further divided into various filters which are linear filter [1], averaging filter, weighted averaging filter, median filter, maximum filter etc.
- **Sharpening Spatial Filter:** This type of filter is used to enhance the details and edges in an image, making it appear sharper and more defined. It is further divided into two filters which are Laplacian filter and unsharp mask filter.

2. Proposed Work

Here in this research work we are evaluating different kernels effects on same digital image that also known as image enhancement, for this jupyter notebook is used where the image can be imported and with the help of open cv, image can be read and displayed, python is also used here. For this evaluation different kernels with different mask are used and their evaluation is done. For convolving the filter with image filter2D() function is used in OpenCV with python the syntax is as:

```
kernel = np.array([[ -1, -1, -1], [-1, 9, -1], [-1, -1, -1]])
kernel.shape

3, 3)

sharp_image=cv2.filter2D(img, -1, kernel)
cv2.imshow('sharp_image')
cv2.waitKey(0)
cv2.destroyAllWindows()
```

Figure 1. Snap Shot of Applying filter2D() Function for Convolution

- **OpenCV:** OpenCV, which stands for Open-Source Computer Vision Library, is an open-source computer vision and machine learning software library designed to facilitate computer vision tasks and image processing.
- **Python:** Python is a high-level, versatile programming language known for its simplicity and readability. Widely used in diverse fields, Python is ideal for web development, data analysis, artificial intelligence, scientific computing, and more.
- **Kernel:** A "kernel" in digital image processing is a small matrix used for operations like filtering and convolution. It plays a crucial role in tasks such as blurring, sharpening, and edge detection, enhancing and extracting features in images. Different kernels yield various effects, making them fundamental for image manipulation and enhancement.

3. Applications

Kernels can serve various purposes, such as:

- **Blurring:** Kernels with equal values are used to reduce noise and create a smooth effect.
- **Sharpening:** Kernels designed to enhance edges and fine details make images appear sharper.

- **Edge Detection:** Specialized kernels are employed to identify edges or boundaries between objects.

4. Methodology

To understand the methodology of this research paper a flow chart is shown below with displaying the simplest steps to go through step wise procedures. First of all, the image is imported in jupyter notebook and then with the help of open cv “imread” command it is read, now the python tool is all set to apply different methods on that digital image. For this research work different kernels is applied on the imported image and results are saved for evaluation to see how different mask of kernels effect the original image and how it is used for further work.

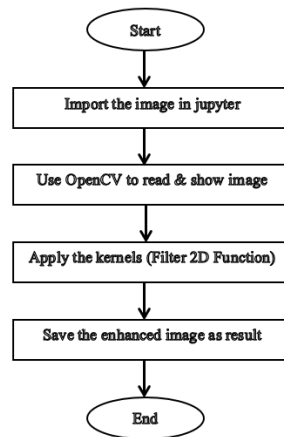







Figure 2. Digital Image Enhancement Process Using OpenCV

5. Result

Results and their evaluation are mentioned below with the help of snap shots of work, a table is mentioned below which consist images of results then their kernel is mentioned and then evaluation description is mentioned.

Table 1. Evaluation Table of Different Results of Image Enhancement Using Different Kernels

Result No.	Original Image (input)	Kernel (convolved onto image)	Enhanced Image (output)	Evaluations (Description)
1.		$\begin{bmatrix} -1, -1, -1, \\ -1, 9, -1, \\ -1, -1, -1 \end{bmatrix}$		Sharpened Image

2.		$[0,-1,0]$, $[-1,5,-1]$, $[0,-1,0]$		Brightened Image
3.		$[1,1,1]$, $[1,1,1]$, $[1,1,1]$		Blurred Image
4.		$[-1,-1,-1]$, $[-1,8,-1]$, $[-1,-1,-1]$		Edge Detection

In this we take original image as a input on that we apply kernel with size $[-1,-1,-1]$, $[-1,9,-1]$, $[-1,-1,-1]$ then it gives a sharpened image. Then we apply kernel with size $[0,-1,0]$, $[-1,5,-1]$, $[0,-1,0]$ which is increasing the center pixel value after 3X3 mask convolution with image therefore we get more bright image. After that, kernel with size $[-1,-1,-1]$, $[-1,8,-1]$, $[-1,-1,-1]$ is applied in which the centre value of each 3X3 mask is decreased by one due to which we get the edge detected. After this, apply kernel on original image with size $[1,1,1]$, $[1,1,1]$, $[1,1,1]$ to get the blurred image.

6. Conclusion

Analysing a digital image using various spatial filtering techniques in image processing allows us to enhance or extract specific features from the image. These techniques are essential for various applications, including image enhancement, noise reduction, edge detection, and object recognition.

References

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