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Image Processing in the Current Scenario

Supriya Kumari

Assistant Professor, Branch-Computer Science & Engineering, Purnea College of Engineering, Purnia, Bihar, India

ABSTRACT

Image processing is the process of transforming an image into a digital form and performing certain operations to get some useful information from it. The image processing system usually treats all images as 2D signals when applying certain predetermined signal processing methods.

There are five main types of image processing:

Visualization - Find objects that are not visible in the image
Recognition - Distinguish or detect objects in the image
Sharpening and restoration - Create an enhanced image from the original image
Pattern recognition - Measure the various patterns around the objects in the image
Retrieval - Browse and search images from a large database of digital images that are similar to the original image

***KEYWORDS:** image, transforming, processing, signals, objects, databases, operations, detect, retrieval*

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INTRODUCTION

Fundamental Image Processing Steps

Image Acquisition

Image acquisition is the first step in image processing. This step is also known as preprocessing in image processing. It involves retrieving the image from a source, usually a hardware-based source.

Image Enhancement

Image enhancement is the process of bringing out and highlighting certain features of interest in an image that has been obscured. This can involve changing the brightness, contrast, etc.

Image Restoration

Image restoration is the process of improving the appearance of an image. However, unlike image enhancement, image restoration is done using certain mathematical or probabilistic models.[1,2]

Color Image Processing

Color image processing includes a number of color modeling techniques in a digital domain. This step has gained prominence due to the significant use of digital images over the internet.

Wavelets and Multiresolution Processing

Wavelets are used to represent images in various degrees of resolution. The images are subdivided into wavelets or smaller regions for data compression and for pyramidal representation.

Compression

Compression is a process used to reduce the storage required to save an image or the bandwidth required to transmit it. This is done particularly when the image is for use on the Internet.

Morphological Processing

Morphological processing is a set of processing operations for morphing images based on their shapes.

Segmentation

Segmentation is one of the most difficult steps of image processing. It involves partitioning an image into its constituent parts or objects. [3,4]

Representation and Description

After an image is segmented into regions in the segmentation process, each region is represented and described in a form suitable for further computer processing. Representation deals with the image's characteristics and regional properties. Description deals with extracting quantitative information that helps differentiate one class of objects from the other.

Recognition

Recognition assigns a label to an object based on its description.

Applications of Image Processing

Medical Image Retrieval

Image processing has been extensively used in medical research and has enabled more efficient and accurate treatment plans. For example, it can be used for the early detection of breast cancer using a sophisticated nodule detection algorithm in breast scans. Since medical usage calls for highly trained image processors, these applications require significant implementation and evaluation before they can be accepted for use.

Traffic Sensing Technologies

In the case of traffic sensors, we use a video image processing system or VIPS. This consists of a) an image capturing system b) a telecommunication system and c) an image processing system. When capturing video, a VIPS has several detection zones which output an "on" signal whenever a vehicle enters the zone, and then output an "off" signal whenever the vehicle exits the detection zone. These detection zones can be set up for multiple lanes and can be used to sense the traffic in a particular station.[5,6]

Besides this, it can auto record the license plate of the vehicle, distinguish the type of vehicle, monitor the speed of the driver on the highway and lots more.

Image Reconstruction

Image processing can be used to recover and fill in the missing or corrupt parts of an image. This involves using image processing systems that have been trained extensively with existing photo datasets to create newer versions of old and damaged photos.

Face Detection

One of the most common applications of image processing that we use today is face detection. It follows deep learning algorithms where the machine is first trained with the specific features of human faces, such as the shape of the face, the distance between the eyes, etc. After teaching the machine these human face features, it will start to accept all objects in an image that resemble a human face. Face detection is a vital tool used in security, biometrics and even filters available on most social media apps these days.[7,8]

Benefits of Image Processing

The implementation of image processing techniques has had a massive impact on many tech organizations. Here are some of the most useful benefits of image processing, regardless of the field of operation:

The digital image can be made available in any desired format (improved image, X-Ray, photo negative, etc)

It helps to improve images for human interpretation

Information can be processed and extracted from images for machine interpretation

The pixels in the image can be manipulated to any desired density and contrast

Images can be stored and retrieved easily

It allows for easy electronic transmission of images to third-party providers[9,10]

Discussion

Image processing is a method to perform some operations on an image, in order to get an enhanced image or to extract some useful information from it. It is a type of signal processing in which input is an image and output may be image or characteristics/features associated with that image. Nowadays, image processing is among rapidly growing technologies. It forms core research area within engineering and computer science disciplines too.

Image processing basically includes the following three steps:

- Importing the image via image acquisition tools;
- Analysing and manipulating the image;
- Output in which result can be altered image or report that is based on image analysis.

There are two types of methods used for image processing namely, analogue and digital image processing. Analogue image processing can be used for the hard copies like printouts and photographs. Image analysts use various fundamentals of interpretation while using these visual techniques. Digital image processing techniques help in manipulation of the digital images by using computers. The three general phases that all types of data have to undergo while using digital technique are pre-processing, enhancement, and display, information extraction.

In this lecture we will talk about a few fundamental definitions such as image, digital image, and digital image processing. Different sources of digital images will be discussed and examples for each source will be provided. The continuum from image processing to computer vision will be covered in this. Finally we will talk about image acquisition and different types of image sensors.[11,12]

Many of the techniques of digital image processing, or digital picture processing as it often was called, were developed in the 1960s, at Bell Laboratories, the Jet Propulsion Laboratory, Massachusetts Institute of Technology, University of Maryland, and a few other research facilities, with application to satellite imagery, wire-photo standards conversion, medical imaging, videophone, character recognition, and photograph enhancement. The purpose of early image processing was to improve the quality of the image. It was aimed for human beings to improve the visual effect of people. In image processing, the input is a low-quality image, and the output is an image with improved quality. Common image processing include image enhancement, restoration, encoding, and compression. The first successful application was the American Jet Propulsion Laboratory (JPL). They used image processing techniques such as geometric correction, gradation transformation, noise removal, etc. on the thousands of lunar photos sent back by the Space Detector Ranger 7 in 1964, taking into account the position of the sun and the environment of the moon. The impact of the successful mapping of the moon's surface map by the computer has been a huge success. Later, more complex image processing was performed on the nearly 100,000 photos sent back by the spacecraft, so that the topographic map, color map and panoramic mosaic of the moon were obtained, which achieved extraordinary results and laid a solid foundation for human landing on the moon.

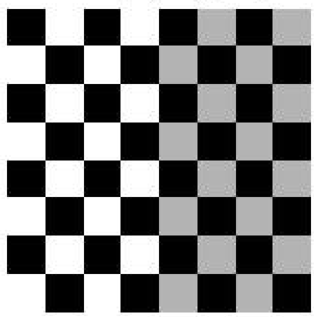
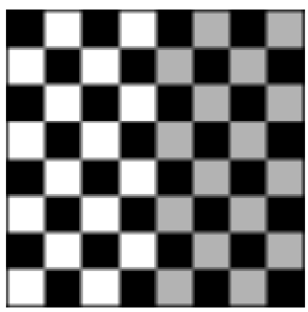
The cost of processing was fairly high, however, with the computing equipment of that era. That changed in the 1970s, when digital image processing proliferated as cheaper computers and dedicated hardware became available. This led to images being processed in real-time, for some dedicated problems such as television standards conversion. As general-purpose computers became faster, they started to take over the role of dedicated hardware for all but the most specialized and computer-intensive operations. With the fast computers and signal processors available in the 2000s, digital image processing has become the most common form of image processing, and is generally used because it is not only the most versatile method, but also the cheapest.

In 1972, the engineer from British company EMI Housfield invented the X-ray computed tomography device for head diagnosis, which is what is usually called CT (computer tomography). The CT nucleus method is based on the projection of the human head section and is processed by computer to reconstruct the cross-sectional image, which is called image reconstruction. In 1975, EMI successfully developed a CT device for the whole body, which obtained a clear tomographic image of various parts of the human body. In 1979, this diagnostic technique won the Nobel Prize. Digital image processing technology for medical applications was inducted into the Space Foundation Space Technology Hall of Fame in 1994

Digital filters are used to blur and sharpen digital images. Filtering can be performed by:

- convolution with specifically designed kernels (filter array) in the spatial domain[25]
- masking specific frequency regions in the frequency (Fourier) domain[13,14]

The following examples show both methods:

Filter type	Kernel or mask	Example
Original Image		Identity (Original) 
Spatial Lowpass		3 × 3 Mean Blur 

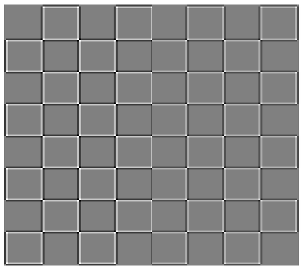
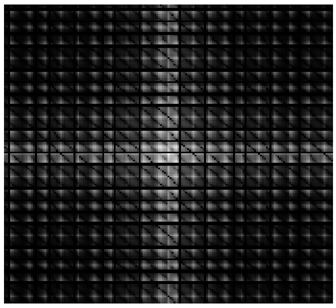
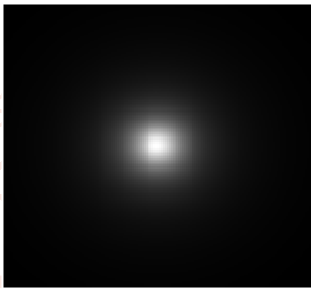
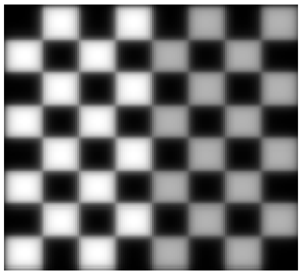
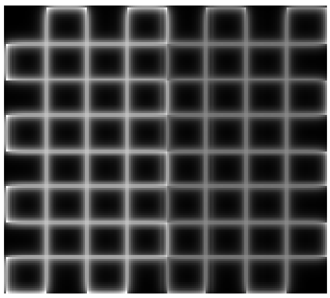
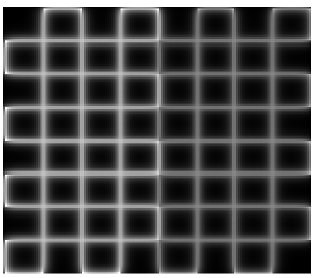
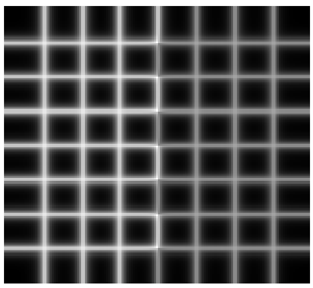
Spatial Highpass		Laplacian Edge Detection 
Fourier Representation	Pseudo-code: image = checkerboard F = Fourier Transform of image Show Image: log(1+Absolute Value(F))	FFT Representation 
Fourier Low pass	Lowpass Butterworth 	FFT Lowpass Filtered 
Fourier Highpass	Highpass Butterworth 	FFT Highpass Filtered 

Image padding in Fourier domain filtering

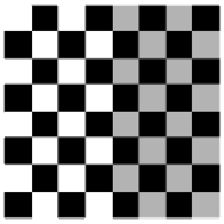
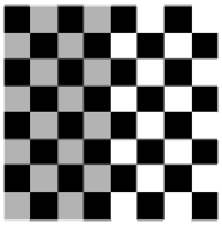
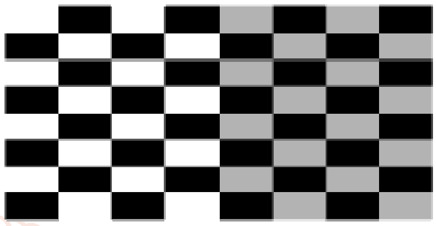
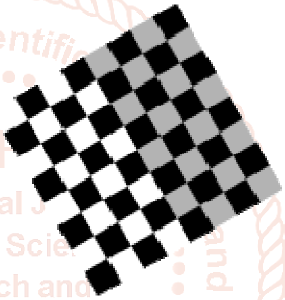
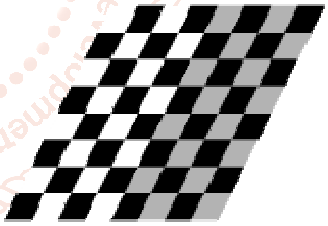
Images are typically padded before being transformed to the Fourier space, the highpass filtered images below illustrate the consequences of different padding techniques:

Zero padded	Repeated edge padded
FFT Highpass Filtered 	FFT Highpass Replicate 

Notice that the highpass filter shows extra edges when zero padded compared to the repeated edge padding.

Affine transformations

Affine transformations enable basic image transformations including scale, rotate, translate, mirror and shear as is shown in the following examples:

Transformation Name	Affine Matrix	Example
Identity		
Reflection		
Scale		
Rotate		 where θ = π/6 =30°
Shear		

To apply the affine matrix to an image, the image is converted to matrix in which each entry corresponds to the pixel intensity at that location. Then each pixel's location can be represented as a vector indicating the coordinates of that pixel in the image, [x, y], where x and y are the row and column of a pixel in the image matrix. This allows the coordinate to be multiplied by an affine-transformation matrix, which gives the position that the pixel value will be copied to in the output image.

However, to allow transformations that require translation transformations, 3 dimensional homogeneous coordinates are needed. The third dimension is usually set to a non-zero constant, usually 1, so that the new coordinate is [x, y, 1]. This allows the coordinate vector to be multiplied by a 3 by 3 matrix, enabling translation shifts. So the third dimension, which is the constant 1, allows translation.[15,16]

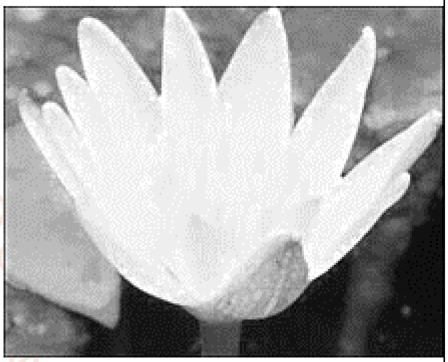
Because matrix multiplication is associative, multiple affine transformations can be combined into a single affine transformation by multiplying the matrix of each individual transformation in the order that the transformations are done. This results in a single matrix that, when applied to a point vector, gives the same result as all the individual transformations performed on the vector [x, y, 1] in sequence. Thus a sequence of affine transformation matrices can be reduced to a single affine transformation matrix.

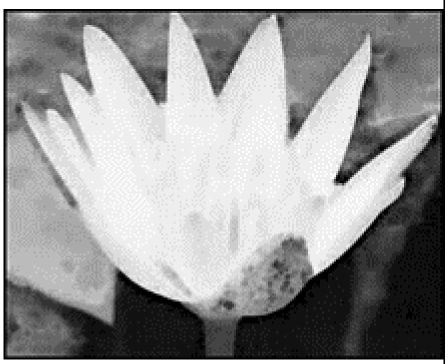
For example, 2 dimensional coordinates only allow rotation about the origin (0, 0). But 3 dimensional homogeneous coordinates can be used to first translate any point to (0, 0), then perform the rotation, and lastly translate the origin (0, 0) back to the original point (the opposite of the first translation). These 3 affine transformations can be combined into a single matrix, thus allowing rotation around any point in the image.

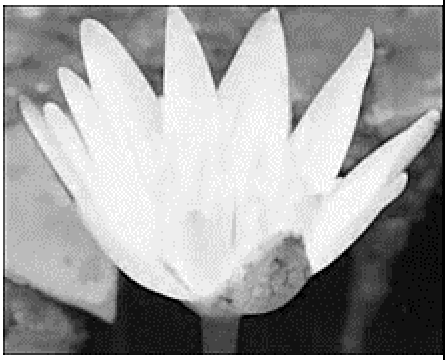
An opening method is just simply erosion first, and then dilation while the closing method is vice versa. In reality, the D(I,B) and E(I,B) can implemented by Convolution

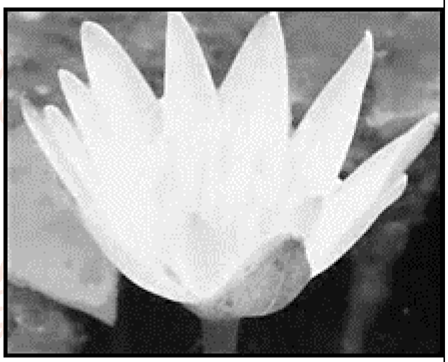
Structuring element	Mask	Code	Example

Original Image	None	Use Matlab to read Original image
		original = imread('scene.jpg');
		image = rgb2gray(original);
		[r, c, channel] = size(image);
		se = logical([1 1 1 ; 1 1 1 ; 1 1 1]);
		[p, q] = size(se);
		halfH = floor(p/2);
		halfW = floor(q/2);
		time = 3; % denoising 3 times with all method
			
			Original lotus

Dilation		Use Matlab to dilation
		imwrite(image, "scene_dil.jpg")
		extractmax = zeros(size(image), class(image));
		for i = 1: time
		dil_image = imread('scene_dil.jpg');
		for col = (halfW + 1): (c - halfW)
		for row = (halfH + 1): (r - halfH)
		dpointD = row - halfH;
		dpointU = row + halfH;
		dpointL = col - halfW;
		dpointR = col + halfW;
		dneighbor = dil_image(dpointD:dpointU,
		dpointL:dpointR);
		filter = dneighbor(se);
		extractmax(row, col) = max(filter);
		end
		end
		imwrite(extractmax, "scene_dil.jpg");
		end
			
			Denoising picture with dilation method

Erosion		Use Matlab to erosion
		imwrite(image, 'scene_ero.jpg');
		extractmin = zeros(size(image), class(image));
		for i = 1: time
		ero_image = imread('scene_ero.jpg');
		for col = (halfW + 1): (c - halfW)
		for row = (halfH +1): (r -halfH)
		pointDown = row-halfH;
		pointUp = row+halfH;
		pointLeft = col-halfW;
		pointRight = col+halfW;
		neighbor =
		ero_image(pointDown:pointUp,pointLeft:pointRigh
		t);
		filter = neighbor(se);
		extractmin(row, col) = min(filter);
		end
		end
		imwrite(extractmin, "scene_ero.jpg");
		end
			

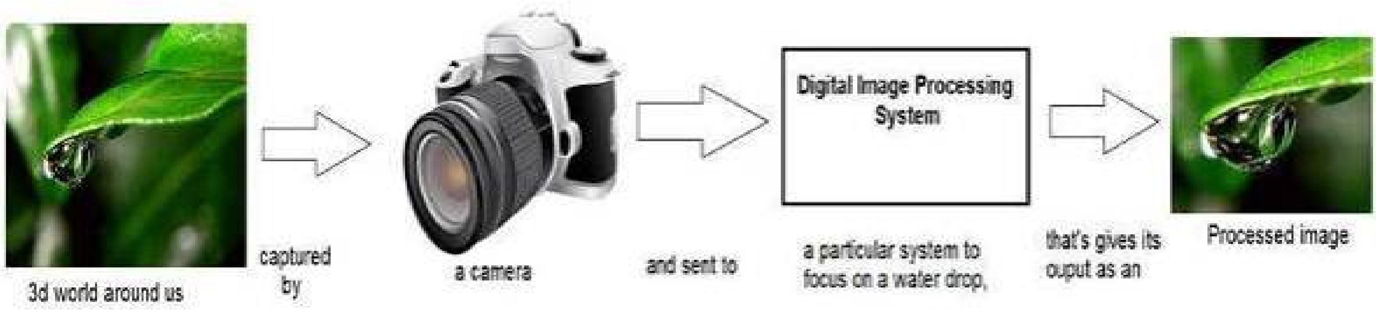
Opening		Use Matlab to Opening
		imwrite(extractmin, "scene_opening.jpg")
		extractopen = zeros(size(image), class(image));
		for i = 1: time
		dil_image = imread('scene_opening.jpg');
		for col = (halfW + 1): (c - halfW)
		for row = (halfH + 1): (r - halfH)
		dpointD = row - halfH;
		dpointU = row + halfH;
		dpointL = col - halfW;
		dpointR = col + halfW;
		dneighbor = dil_image(dpointD:dpointU, dpointL:dpointR);
		filter = dneighbor(se);
		extractopen(row, col) = max(filter);
		end
		end
		imwrite(extractopen, "scene_opening.jpg");
		end
			

Closing		Use Matlab to Closing
		imwrite(extractmax, "scene_closing.jpg")
		extractclose = zeros(size(image), class(image));
		for i = 1: time
		ero_image = imread('scene_closing.jpg');
		for col = (halfW + 1): (c - halfW)
		for row = (halfH + 1): (r - halfH)
		dpointD = row - halfH;
		dpointU = row + halfH;
		dpointL = col - halfW;
		dpointR = col + halfW;
		dneighbor = ero_image(dpointD:dpointU, dpointL:dpointR);
		filter = dneighbor(se);
		extractclose(row, col) = min(filter);
		end
		end
		imwrite(extractclose, "scene_closing.jpg");
		end
			
			Denoising picture with closing method

Results

Digital image processing deals with manipulation of digital images through a digital computer. It is a subfield of signals and systems but focus particularly on images. DIP focuses on developing a computer system that is able to perform processing on an image. The input of that system is a digital image and the system process that image using efficient algorithms, and gives an image as an output. The most common example is Adobe Photoshop. It is one of the widely used application for processing digital images.[17]

How it works.



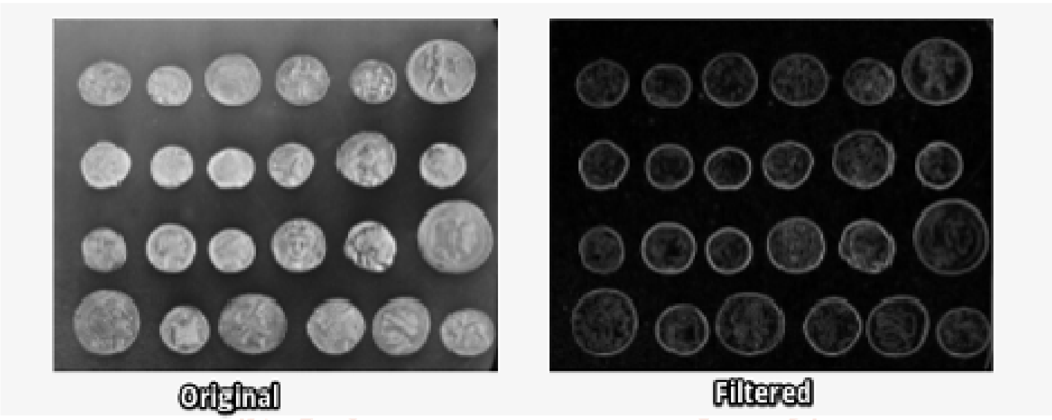
In the above figure, an image has been captured by a camera and has been sent to a digital system to remove all the other details, and just focus on the water drop by zooming it in such a way that the quality of the image remains the same.

Libraries involved in Image Processing

The following libraries are involved in performing Image processing in python;

- Scikit-image
- OpenCV
- Mahotas
- SimpleITK
- SciPy
- Pillow
- Matplotlib

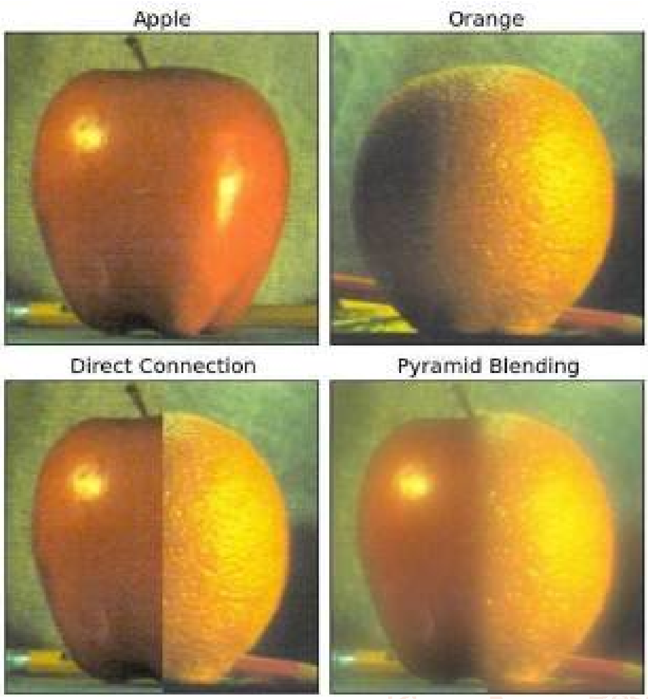
Scikit-image is an open-source Python package run by the same NumPy members. It uses algorithms and resources for research, academic and industrial use. It is a simple and straightforward library, even for newcomers to Python's ecosystem. The code is high quality, reviewed by peers, and written by a working community of volunteers.[18]



SciPy is one of Python's basic science modules (like NumPy) and can be used for basic deception and processing tasks. In particular, the submodule scipy.ndimage (in SciPy v1.1.0) provides functions that work on n-dimensional NumPy arrays. The package currently includes direct and offline filtering functions, binary morphology, B-spline translation, and object ratings.

PIL (Python Imaging Library) is a free Python programming language library that adds support for opening, managing, and storing multiple image file formats. However, its development has stalled, with the last release in 2009. Fortunately, there is a Pillow, a PIL-shaped fork, easy to install, works on all major operating systems, and supports Python 3. Color-space conversions.

OpenCV (Open Source Computer Vision Library) is one of the most widely used libraries in computer programming. OpenCV-Python is an OpenCV Python API. OpenCV-Python is not only running, because the background has a code written in C / C ++, but it is also easy to extract and distribute (due to Python folding in the front). This makes it a good decision to make computer vision programs more robust.[19,20]



Mahotas is another Python computer and graphics editor. It contains traditional image processing functions such as morphological filtering and functioning, as well as modern computer-assisted computational computation functions, including the discovery of point of interest and local definitions. The display is in Python, which is suitable for rapid development, but the algorithms are used in C ++ and are fixed at speed. The Mahotas Library is fast with little code and with little reliance.

Image processing is often regarded as improperly exploiting the image in order to achieve a level of beauty or to support a popular reality. However, image processing is most accurately described as a means of translation between a human viewing system and digital imaging devices. The human viewing system does not see the world in the same way as digital cameras, which have additional sound effects and bandwidth. Significant differences between human and digital detectors will be demonstrated, as well as specific processing steps to achieve translation. Image editing should be approached in a scientific way so that others can reproduce, and validate human results. This includes recording and reporting processing actions and applying the same treatment to adequate control images.[20]

Conclusions

Image processing is a way of doing certain tasks in an image, to get an improved image or to extract some useful information from it. It is a type of signal processing where the input is an image and the output can be an image or features/features associated with that image. Today, image processing is one of the fastest-growing technologies. It creates a major research space within engineering and computer science as well. Check out the image processing course and understand the details of the image processing concept.[20]

Image processing basically involves the following three steps:

Image import with image detection tools;

Image analysis and management;

The result of which an image or report based on image analysis can be changed.

There are two types of image processing methods, namely analogue and digital image processing. Analogue image processing can be used for hard copies such as printing and photography. Image analysts use a variety of translation bases while using these viewing methods. Digital image processing techniques facilitate the use of digital images using computers. The three common categories that all types of data are required to use when using the digital process are pre-processing, development, and display of information.[21]

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