Southwest University of Science and Technology

Subject: Academic Report

Topic: Image Processing

Source code: https://github.com/Pollob001/Image_Processing

Southwest University of Science and Technology

Department of Computer Science and Technology

Student Name: MD AYNUL ISLAM

Chinese Name: 叶子

Student ID: 4420190030

Batch: Undergraduate 2019

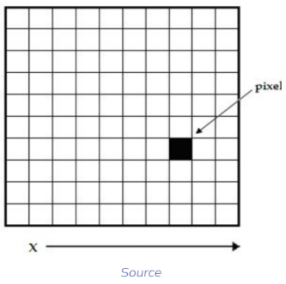
Contents

1 Abstract

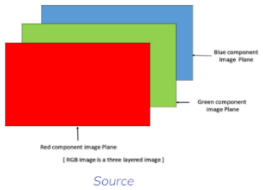
Image processing, set of computational techniques for analyzing, enhancing, compressing, and reconstructing images. Its main components are importing, in which an image is captured through scanning or digital photography; analysis and manipulation of the image, accomplished using various specialized software applications; and output to a printer or monitor. Image processing has extensive applications in many areas, including astronomy, medicine, industrial robotics, and remote sensing by satellites. This workshop provides an introduction to basic image processing techniques using the OpenCV computer vision library and some standard data analysis libraries in Python.

2 Introduction

Digital image processing is the use of a digital computer to process digital images through an algorithm. As a subcategory or field of digital signal processing, digital image processing has many advantages over analog image processing. It allows a much wider range of algorithms to be applied to the input data and can avoid problems such as the build-up of noise and distortion during processing. Since images are defined over two dimensions (perhaps more) digital image processing may be modeled in the form of multidimensional systems. The generation and development of digital image processing are mainly affected by three factors: first, the development of computers; second, the development of mathematics (especially the creation and improvement of discrete mathematics theory); third, the demand for a wide range of applications in environment, agriculture, military, industry and medical science has increased.[1]



Source


Source

[Source](#) of the image

3 Origin of Digital Image

The first application of digital image was in the newspaper industry when the pictures were first sent by submarine cable between London and New York.

The cable picture transmission in 1921 reduced the time required to transport a picture across the Atlantic for more than a week to less than 3 hours.

A digital picture produced in 1921 from a coded tape by a telegraph printer with special type faces.

Source of the image

4 Objectives

- Improvement on pictorial information for human interpretation
- Processing of image data for storage, transmission and representation for autonomous machine perception.

5 Types of Images

5.1 BINARY IMAGE

The binary image as its name suggests, contain only two pixel elements i.e 0 & 1,where 0 refers to black and 1 refers to white. This image is also known as Monochrome.

5.2 BLACK AND WHITE IMAGE

The image which consist of only black and white color is called BLACK AND WHITE IMAGE.

5.3 8 bit COLOR FORMAT

It is the most famous image format. It has 256 different shades of colors in it and commonly known as Grayscale Image. In this format, 0 stands for Black, and 255 stands for white, and 127 stands for gray.

5.4 16 bit COLOR FORMAT

It is a color image format. It has 65,536 different colors in it. It is also known as High Color Format. In this format the distribution of color is not as same as Grayscale image.

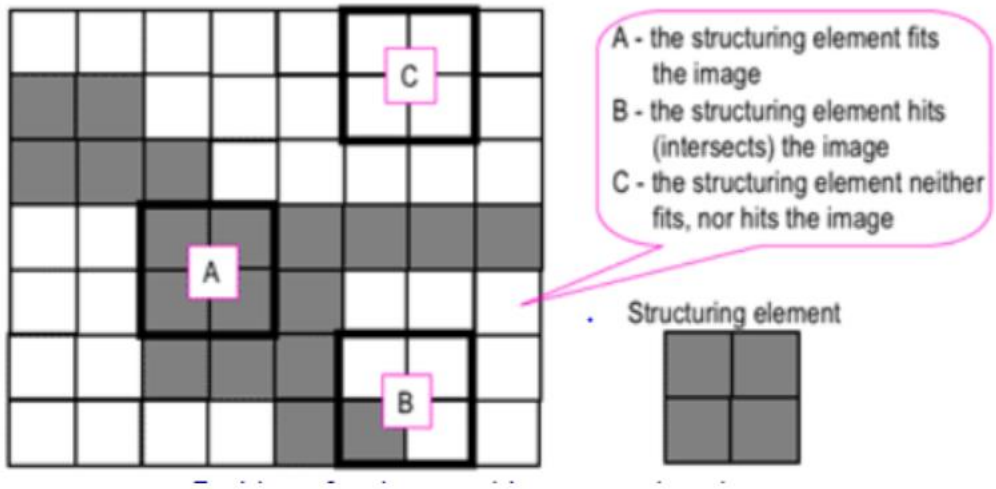
A 16 bit format is actually divided into three further formats which are Red, Green and Blue. That famous RGB format.[2]

6 Classic image processing algorithms

6.1 Morphological Image Processing

Morphological image processing tries to remove the imperfections from the binary images because binary regions produced by simple thresholding can be distorted by noise. It also helps in smoothing the image using opening and closing operations.

Morphological operations can be extended to grayscale images. It consists of non-linear operations related to the structure of features of an image. It depends on the related ordering of pixels but on their numerical values. This technique analyzes an image using a small template known as structuring element which is placed on different possible locations in the image and is compared with the corresponding neighbourhood pixels. A structuring element is a small matrix with 0 and 1 values.



Source of the image

The zero-one pattern defines the configuration of the structuring element. It's according to the shape of the object we want to select. The center of the structuring element identifies the pixel being processed.

6.2 Gaussian Image Processing

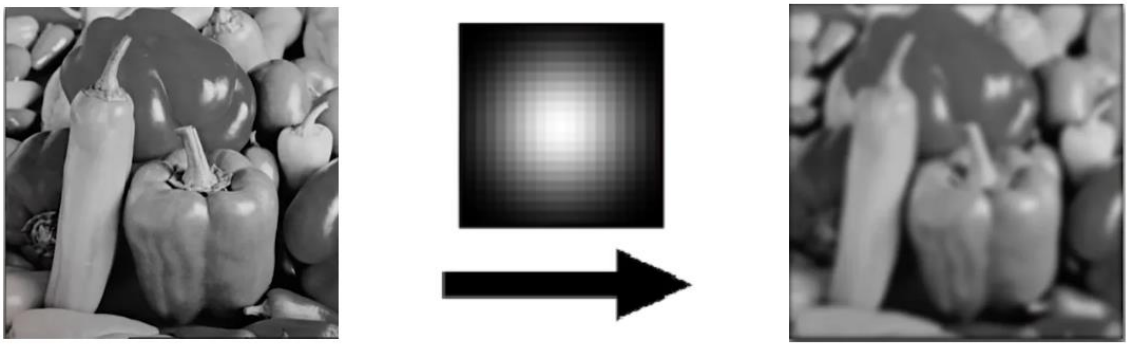
Gaussian blur which is also known as gaussian smoothing, is the result of blurring an image by a Gaussian function.

It is used to reduce image noise and reduce details. The visual effect of this blurring technique is similar to looking at an image through the translucent screen. It is sometimes used in computer vision for image enhancement at different scales or as a data augmentation technique in deep learning.

The basic gaussian function looks like:

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

In practice, it is best to take advantage of the Gaussian blur's separable property by dividing the process into two passes. In the first pass, a one-dimensional kernel is used to blur the image in only the horizontal or vertical direction. In the second pass, the same one-dimensional kernel is used to blur in the remaining direction. The resulting effect is the same as convolving with a two-dimensional kernel in a single pass. Let's see an example to understand what gaussian filters do to an image.

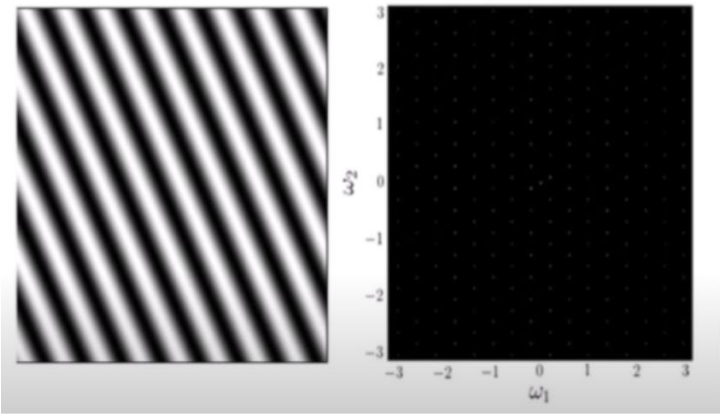


Source of the image

Now, we can see that some of the edges have little less detail. The filter is giving more weight to the pixels at the center than the pixels away from the center. Gaussian filters are low-pass filters weakens the high frequencies. It is commonly used in edge detection.

6.3 Fourier Transform in image processing

Fourier transform breaks down an image into sine and cosine components. It has multiple applications like image reconstruction, image compression, or image filtering. Since we are talking about images, we will take discrete fourier transform into consideration.



Source of the image

The formula for 2D discrete fourier transform is:

$$F(u, v) = \frac{1}{MN} \sum_{x=0}^{M-1} \sum_{y=0}^{N-1} f(x, y)\, e^{-j2\pi\left(\frac{ux}{M}+\frac{vy}{N}\right)}$$

In the above formula, f(x,y) denotes the image.[3]

The inverse fourier transform converts the transform back to image. The formula for 2D inverse discrete fourier transform is:

$$f(x, y) = \sum_{u=0}^{M-1} \sum_{v=0}^{N-1} F(u, v)\, e^{j2\pi\left(\frac{ux}{M}+\frac{vy}{N}\right)}$$

6.4 Edge Detection in image processing

Edge detection is an image processing technique for finding the boundaries of objects within images. It works by detecting discontinuities in brightness. This could be very beneficial in extracting useful

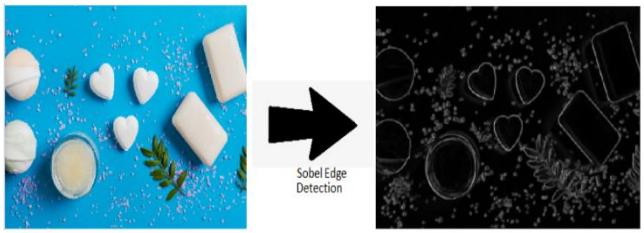
information from the image because most of the shape information is enclosed in the edges. Classic edge detection methods work by detecting discontinuities in the brightness.

$$Gx = \begin{bmatrix} 1 & 0 & -1 \\ 2 & 0 & -2 \\ 1 & 0 & -1 \end{bmatrix} * Image\ matrix$$

And,

$$Gy = \begin{bmatrix} 1 & 2 & 1 \\ 0 & 0 & 0 \\ -1 & -2 & -1 \end{bmatrix} * Image\ matrix$$

$$G = sqrt(Gx^2 + Gy^2)$$



The most common edge detection algorithm is sobel edge detection algorithm. Sobel detection operator is made up of 3*3 convolutional kernels. A simple kernel Gx and a 90 degree rotated kernel Gy. Separate measurements are made by applying both the kernel separately to the image.[4]

6.5 Wavelet Image Processing

We saw a Fourier transform but it is only limited to the frequency. Wavelets take both time and frequency into the consideration. This transform is apt for non-stationary signals. We know that edges are one of the important parts of the image, while applying the traditional filters it's been noticed that noise gets removed but image gets blurry. The wavelet transform is designed in such a way that we get good frequency resolution for low frequency components. Below is the 2D wavelet transform example:

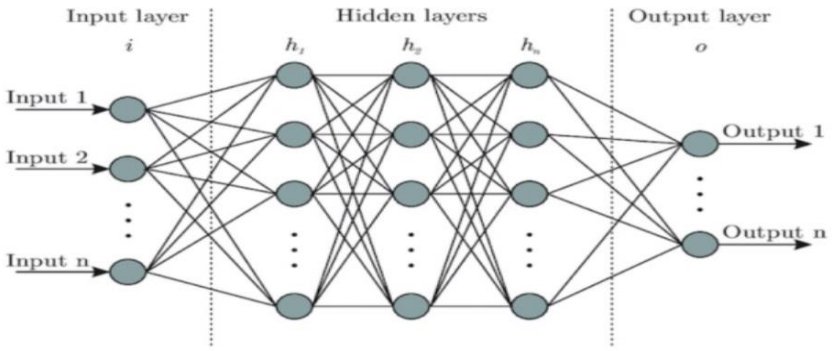
Source of the image

7 Image processing using Neural Networks

Neural Networks are multi-layered networks consisting of neurons or nodes. These neurons are the core processing units of the neural network. They are designed to act like human brains. They take in data, train themselves to recognize the patterns in the data and then predict the output.

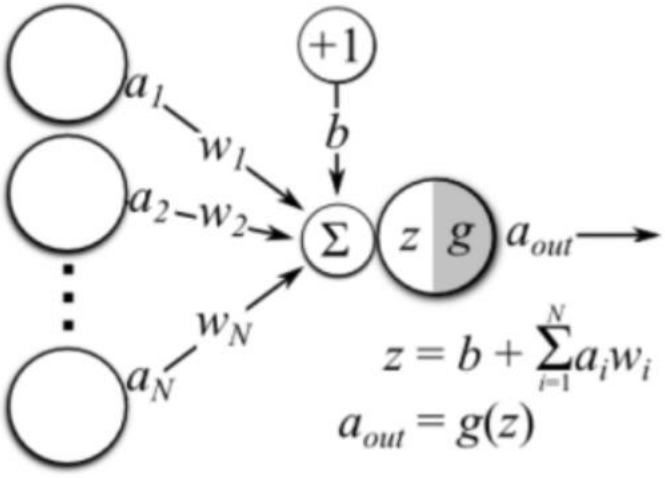
A basic neural network has three layers:

- Input layer
- Hidden layer
- Output layer



Basic neural network | Source

The input layers receive the input, the output layer predicts the output and the hidden layers do most of the calculations. The number of hidden layers can be modified according to the requirements. There should be atleast one hidden layer in a neural network.



Operations in a single neuron | Source

More data needs to be fed to the model to get the better results. Image dataset should be of high quality to get more clear information, but to process them you may require deeper neural networks. In many cases RGB images are converted to grayscale before feeding them into a neural network.[5]

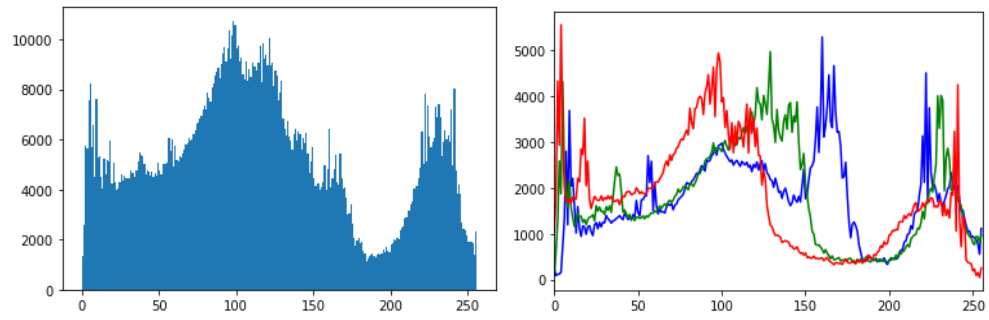
8 Code Implementation and Results

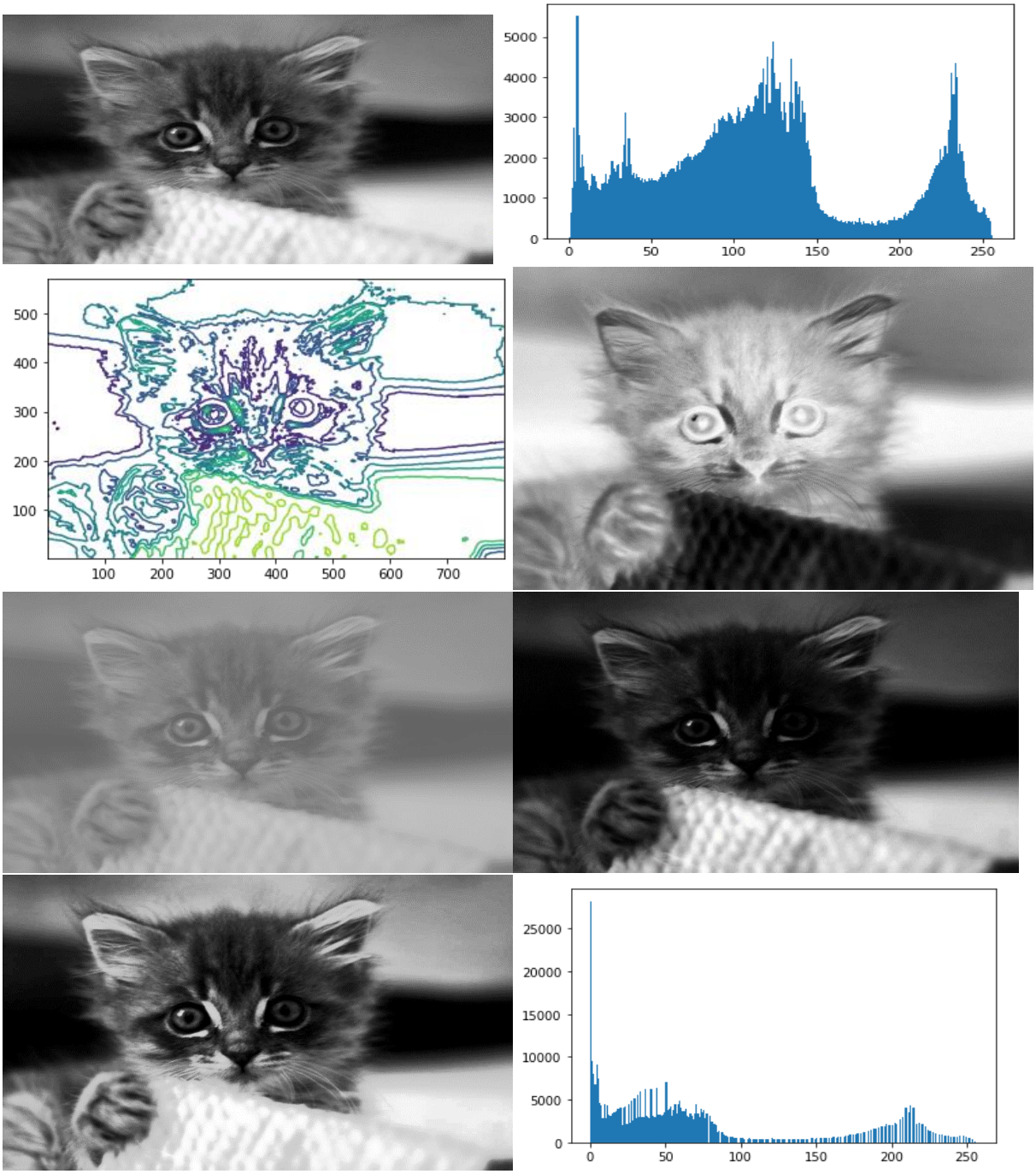
This workshop provides an introduction to basic image processing techniques using the OpenCV computer vision library and some standard data analysis libraries in Python.

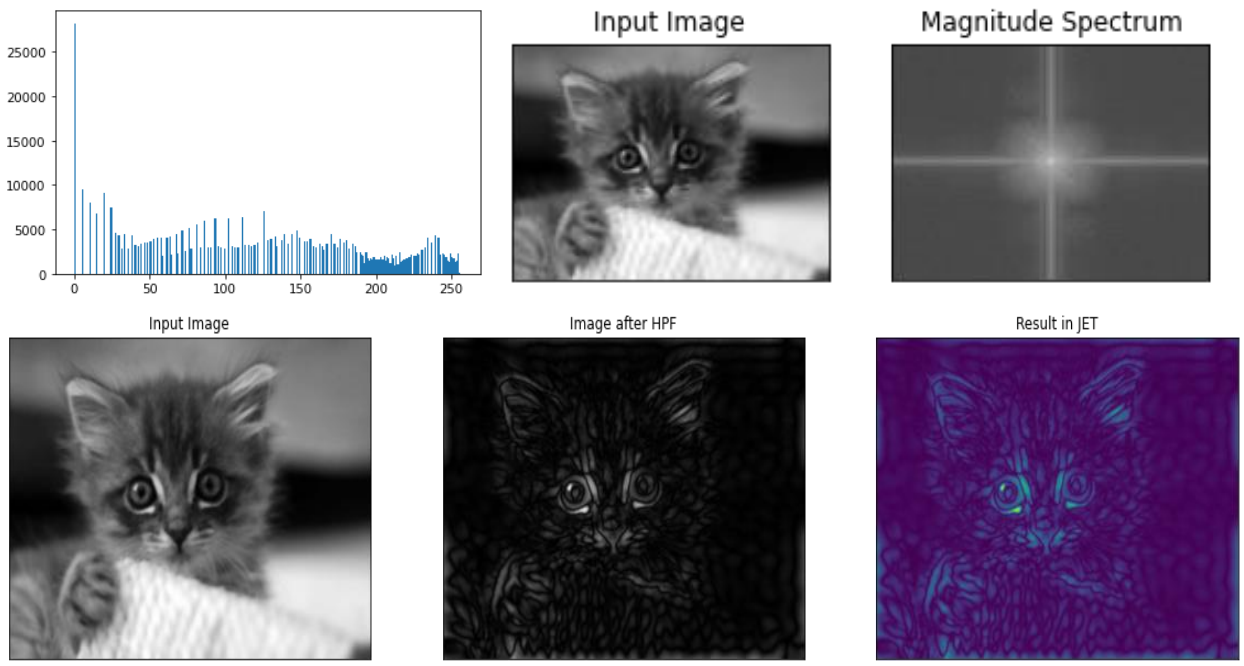
In this part I am going to attach the github link. There I upload all the code.

Source code: Image Processing in Python

Results OutPut Pictures




5000
4000
3000
2000
1000
0
0
50
100
150
200
250
500
400
300
200
100
100
200
300
400
500
600
700
25000
20000
15000
10000
5000
0
0
50
100
150
200
250



9 Image processing tools

Image processing is a very useful technology and the demand from the industry seems to be growing every year. Historically, image processing that uses machine learning appeared in the 1960s as an attempt to simulate the human vision system and automate the image analysis process. As the technology developed and improved, solutions for specific tasks began to appear.

Image Processing filters transform digital images.

They are quite easy to implement using either Processing or Python.

DIY Filters

Processing makes it simple to handle images, iterate over the pixels of an image and perform operations on them.

Standard Filters

Processing comes loaded with a bunch of filters that are commonly used in Image processing programs such as Photoshop or the Gimp.

- filter() in the Processing Reference
- Standard Filter examples from Coding Gestalt

GPU Filters

You can also implement filters using OpenGL pixelshaders. These harness the power of the GPU.

OpenCV Filters

OpenCV offers all kinds of algorithms from basic image processing to advanced computer vision. The OpenCV library for processing provides access to those.

- OpenCV Website
- OpenCV Processing Library
- OpenCV Examples from Coding Gestalt

Python Tools

PIL

The Python Imaging Library provides you with the power to handle and process images. Multimedia Programming Tutorials by the Software Carpentry:

- Images
- Image Operations

SciKit-Image

Scikit-image is a collection of algorithms for image processing.

- Scikit-Image Homepage
- Scikit-Image Gallery

SimpleCV

SimpleCV is a python wrapper for OpenCV (and a couple of other tools) that makes image processing really easy.

Dataflow Tools

FilterForge

FilterForge is a commercial application that lets you create filters using a node based dataflow programming language.[6]

It can be used as a Plugin for Adobe Photoshop, and has crodsourced over 10.000 Image Processing Filters.

- Filter Forge Website
- Filter Forge Filters

10 Phases Of Image Processing

ACQUISITION

It could be as simple as being given an image which is in digital form. The main work involves:

- Scaling
- Color conversion(RGB to Gray or vice-versa)

IMAGE ENHANCEMENT

It is amongst the simplest and most appealing in areas of Image Processing it is also used to extract some hidden details from an image and is subjective.

IMAGE RESTORATION

It also deals with appealing of an image but it is objective (Restoration is based on mathematical or probabilistic model or image degradation).

COLOR IMAGE PROCESSING

It deals with pseudocolor and full color image processing color models are applicable to digital image processing.

WAVELETS AND MULTI-RESOLUTION PROCESSING

It is foundation of representing images in various degrees.

IMAGE COMPRESSION

It involves in developing some functions to perform this operation. It mainly deals with image size or resolution.

MORPHOLOGICAL PROCESSING

t deals with tools for extracting image components that are useful in the representation & description of shape.

SEGMENTATION PROCEDURE

It includes partitioning an image into its constituent parts or objects. Autonomous segmentation is the most difficult task in Image Processing.

REPRESENTATION & DESCRIPTION

It follows output of segmentation stage, choosing a representation is only the part of solution for transforming raw data into processed data.

OBJECT DETECTION AND RECOGNITION

It is a process that assigns a label to an object based on its descriptor.[7]

11 Applications of Image Processing

Some of the major fields in which digital image processing is widely used are mentioned below

11.1 Medical Field

Medical image processing encompasses the use and exploration of 3D image datasets of the human body, obtained most commonly from a Computed Tomography (CT) or Magnetic Resonance Imaging (MRI) scanner to diagnose pathologies or guide medical interventions such as surgical planning, or for research purposes.

11.2 Remote Sensing

Remote sensing is the process of detecting and monitoring the physical characteristics of an area by measuring its reflected and emitted radiation at a distance (typically from satellite or aircraft). Special cameras collect remotely sensed images, which help researchers "sense" things about the Earth.

11.3 Machine/Robot vision

Apart form the many challenges that a robot face today, one of the biggest challenge still is to increase the vision of the robot. Make robot able to see things, identify them, identify the hurdles e.t.c. Much work has been contributed by this field and a complete other field of computer vision has been introduced to work on it.

11.4 Video processing

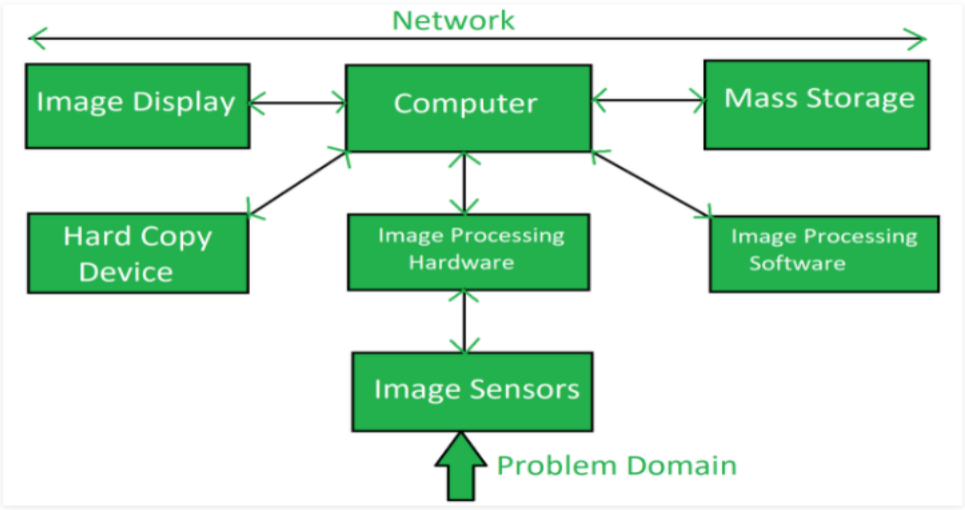
A video is nothing but just the very fast movement of pictures. The quality of the video depends on the number of frames/pictures per minute and the quality of each frame being used. Video processing involves noise reduction, detail enhancement, motion detection , frame rate conversion , aspect ratio conversion , color space conversion

11.5 Pattern Recognition

Pattern recognition involves study from image processing and from various other fields that includes machine learning. In pattern recognition, image processing is used for identifying the objects in an images and then machine learning is used to train the system for the change in pattern. Pattern recognition is used in computer aided diagnosis, recognition of handwriting, recognition of images.

12 Components of Image Processing

Image Processing System is the combination of the different elements involved in the digital image processing. Digital image processing is the processing of an image by means of a digital computer. Digital image processing uses different computer algorithms to perform image processing on the digital images.



Source of the image

Image Sensors

Image sensors senses the intensity, amplitude, co-ordinates and other features of the images and passes the result to the image processing hardware. It includes the problem domain.

Image Processing Hardware

Image processing hardware is the dedicated hardware that is used to process the instructions obtained from the image sensors. It passes the result to general purpose computer.

Computer

Computer used in the image processing system is the general purpose computer that is used by us in our daily life.

Image Processing Software

Image processing software is the software that includes all the mechanisms and algorithms that are used in image processing system.

Mass Storage

Mass storage stores the pixels of the images during the processing.

Hard Copy Device

Once the image is processed then it is stored in the hard copy device. It can be a pen drive or any external ROM device.

Image Display

It includes the monitor or display screen that displays the processed images.

Network

Network is the connection of all the above elements of the image processing system.[8]

13 Image Processing Applications in Research

Image processing techniques use filters to enhance an image. Their main applications are to transform the contrast, brightness, resolution and noise level of an image. Contouring, image sharpening, blurring, embossing and edge detection are typical image processing functions

- Document Handling and Signature Verification
- Biometric application
- Fingerprint verification/identification

- Object Recognition
- Target Recognition – Department of defence (Army, navy and airforce)
- Interpretation of aerial photography – Google Maps is an example
- Traffic Monitoring
- Face Detection
- Face Recognition
- Morphing
- Skin and breast cancer
- Human Activity Recognition
- Facial Expression Recognition

14 Conclusion

With the approach of quick and modest machines, computerized picture handling has turned into a profoundly requested field of study and practice. It gives answers for different genuine applications monetarily. Different strategies have been created to construct canny frameworks; large numbers of them are underway at different offices universally. This part has given some starting notes on picture handling, its short history, procedures, undertakings, programming, and applications. It will assist with kicking start the local area intrigued to have some skill on the picture handling subject. The fate of computerized picture handling has a high likelihood to contribute toward the form of savvy and astute world as far as wellbeing, schooling, guard, traffic, homes, workplaces, urban areas, and so on.

15 Reference

[1] K. Teostus and G. Anbarjafari, “1. Introduction to image processing | Digital Image Processing,” *OpenScholar*, 2004. https://sisu.ut.ee/imageprocessing/book/1 (accessed Dec. 19, 2021).

[2] “Image Transformation | Digital Image Processing System - Javatpoint.” https://www.javatpoint.com/dip-image-transformations (accessed Dec. 19, 2021).

[3] “What is Digital Image Processing (DIP),” *Mygreatlearning*, 2020. https://www.mygreatlearning.com/blog/digital-image-processing-explained/ (accessed Dec. 19, 2021).

[4] N. Khandelwal, “Image Processing in Python: Algorithms, Tools, and Methods You Should Know - neptune.ai,” 2021. https://neptune.ai/blog/image-processing-in-python-algorithms-tools-and-methods-you-should-know (accessed Dec. 19, 2021).

[5] Rafael c. gonzalez, “Digital Image Processing Basics - GeeksforGeeks,” 2018. https://www.geeksforgeeks.org/digital-image-processing-basics/ (accessed Dec. 19, 2021).

[6] “Best Image Processing Tools Used in Machine Learning - neptune.ai.” https://neptune.ai/blog/best-image-processing-tools-used-in-machine-learning (accessed Dec. 28, 2021).

[7] T. S. Huang, J. W. Burnett, and A. G. Deczky, “The Importance of Phase in Image Processing Filters,” *IEEE Trans. Acoust.*, vol. 23, no. 6, pp. 529–542, 1975, doi: 10.1109/TASSP.1975.1162738.

[8] M. Sarfraz, “Introductory Chapter: On Digital Image Processing,” *Digit. Imaging*, May 2020, doi: 10.5772/intechopen.92060.