# A Survey on Image Processing Applications and Techniques

Sara Sarrafan Chaharsoughi
Student, Masters in Applied Computing
Wilfrid Laurier University
Waterloo (ON), Canada
Sarr6790@mylaurier.ca

***Abstract*—Image processing is now a very vital tool for analysis in numerous fields and applications. Digital Image processing mainly has two broadly categorized application areas: improving pictorial information for better interpretation; and image data processing for representation, storage, or transmission to facilitate machine learning and data analysis. This paper attempts to demarcate the scope and meaning of Image Processing; examine the various applications and methodologies of top image processing tools, and also discuss a few different techniques used for Image Processing. The techniques discussed are mostly involved in enhancing image clarity, reducing image noise, and compressing the original image to reduce space.**

***Keywords—Image processing, pictorial information, machine learning, data analysis, image clarity, image noise***

## I. Introduction

In image processing, you perform some operations on an image in order to improve it, classify it, or get some useful information from it. The two main methods of image processing are analog and digital for hard copies, such as prints and photos, analog image processing can be used instead. While using these techniques, image analysts utilize a variety of fundamentals to interpret the images. A computer is used to manipulate digital images using digital image processing techniques. As images are everywhere in our life, image processing has attracted the attention of researchers in the last decades. Each image has a lot of information that can help humans in different ways. Open-source tools help image processing and make programming easier and help companies and start-ups to develop and improve their own machine learning apps and algorithms. After processing the raw data, it will be converted to an understandable form for a machine.

## II. Applications Of Image Processing

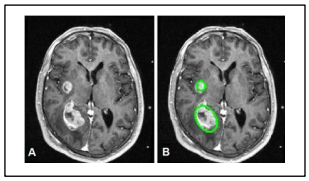
Image processing is now one of the crux technology of many applications and frontier areas of research. Each of these applications has unique and specific requirements, all of which are fulfilled by the processing of image data into information. A few of these leading examples in today's world are discussed below:

### *A. Robot Vision*

Software, robots, and special lighting make up a robot vision system. The software analyzes the captured image for features that indicate the robot's position and orientation, then uses these to determine its position. Detects distance between hurdle and robot. For example, Drones.

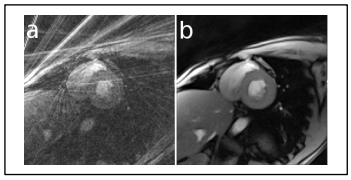
### *B. Medical Field*

Since the advancement in medical techniques and equipment, Image Processing is playing a vital role in this advancement. Techniques of image processing are being used in the diagnosis of many different diseases by detecting differences in patterns of X-Rays. The program recognizes multiple MRIs and detects small oddities that cannot be seen with human eyes.



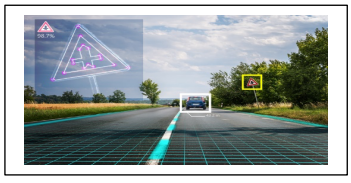

### *C. Reconstruction of Images*

Images In this era of the digital world, thousands of images are being made every day. Some of the images are being corrupted or distorted. To restore the images, techniques of image processing are being used to reinstate these images.



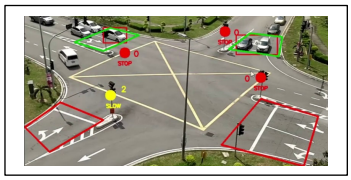

### *D. Automated Cars*

Self-driving cars use image processing to detect obstacles. Simple and effective, it involves outfitting a car with cameras that can take control of all the objects around it and alert the driver when they are in the way of the car. Put in-car computers in charge of navigating themselves so they can learn the rules of the road.



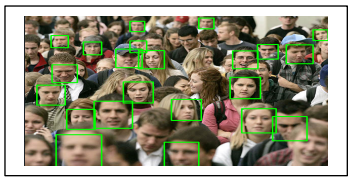
### *E. Traffic Controlling Technology*

As urbanization continues to grow, traffic is one of the most common effects, but modern technologies for traffic management will help reduce traffic problems and consequently commute times. Using image processing to detect the flow of traffic and control traffic lights accordingly.



### F. *Face Detection for Security (Deep learning algorithms)*

Facial recognition is a method of identifying or verifying a person's face through a digital image or video frame. For example, detecting a face to recognize a person or to unlock smartphones. Algorithms are used in facial recognition systems. A computer recognizes data like we do when we see a face. It records information about the faces of each individual.

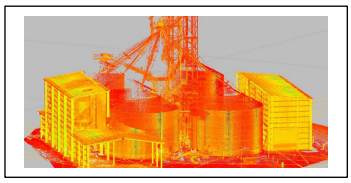


### G. *Vehicle License Plate Recognition*

Car number plate recognition is one of the applications that use algorithms of image processing. It is used to distinguish between different types of vehicles. It is being used by police to get the picture of the license plate number of a vehicle that breaks any law or traffic signal.

### H. *Multi-Dimensional Image Processing*

Multi-dimensional image processing algorithms are being used by many applications. It is being used by architects to make a 3D model of a building and observing any flaws that are in that model and then work on that defect to fix it. It is also being used by 3D printers.

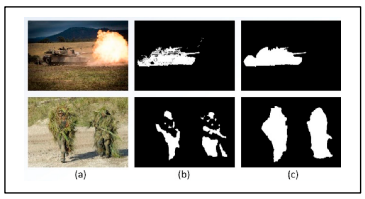


### I. *Grayscale Picture to Colored Image*

Old images are very important for everyone as they have many memories in them. There was no advanced technology back in time because of that, images were grayscale at that time. Image processing techniques help to turn grayscale images into colored images.

### J. *Military Equipment*

Advancement in technology is bringing advancement in military equipment as well. Image processing plays important role in that by detecting hidden targets and recognizing objects. It processes the images taken and processes it to identify targets as well.

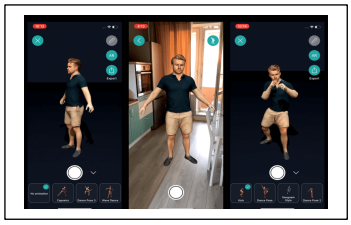



### K. *Superstores (Walmart labs)*

Marketing techniques are innovating day by day to increase sales. Walmart Labs used the camera to detect the eye movement of customers and process it accordingly to increase sales. As they detected eye movement of customer's kid and observe which product they look at and placing it in their range to increase sales.

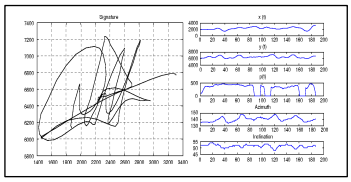
### L. *Gaming*

Gaming is a big market of sales and as time passes it is being advanced so gamers can be attracted more to games. 3D image processing techniques are being used to improvise how gamers interact with games. For example, Xbox Kinect uses 3D image processing to give gamers a real-world experience in-game by scanning a gamer and creating a character that looks like a gamer and by copying their actions in the game.



### M. *Signature Recognition*

In the process of generating a signature, behavioral patterns are essential to detecting and storing a signature. There are many factors that are analyzed include the speed, variations in timing, and the pressure applied to the pen when an individual composes a signature. Using image processing we can match signatures with original signatures stored in the system.



### N. *Biometric Verification*

Biometric verification is the method that verifies a person's unique identity. The image of a fingerprint of a person is retrieved from a biometric machine and then it is being processed using image processing algorithms and then it identifies if the person is the same, who should be authorized or not.

## III. Method Of Image Processing

Digital image data processing is essentially a computer taking digital images as input and converting the spatially distributed continuous image model to a discrete digital entity to help carry out further processing of digital image information.

A two-dimensional signal is all that an image is. It can be represented as a signal function *f(x,y)*, where the value of *x* and *y* are the coordinates of a pixel of the image. Hence, images are two-dimensional arrays with numbers between 0 and 255.

### *A. Image Obtainment*

Removing unwanted noise and improving images by using image processing techniques are smoothing and sharpening. Image Pre-processing techniques used are scaling, transforming, zooming, resizing, and converting images to greyscale images.[1]

### *B. Preprocessing*

Enhancing and removing distortion of an image to process.

### *C. Detection and Segmentation of Edges*

Detecting edges and dividing them into segments to better analyze an image.

### *D. Image Restoration*

Improving image quality.

### *E. Output Image*

Obtaining an improvised image.

## IV. Image Recognition And Image Processing Techniques

Digital image processing is an amalgamation of techniques and methods that help in the manipulation of images on a computer. It has a variety of applications, including image segmentation, image restoration, image recognition, and consists mainly of the following techniques:

### *A. Convolutional neural network (CNN)*

CNNs are widely used in image recognition, pattern identification, speech recognition, etc. There are usually one or more convolutional levels, pooling levels, and fully connected levels in a CNN model. CNN is designed to automatically and adaptively learn spatial hierarchies of features, from low-level models to high-level models. CNN is a mathematical construct that is typically made up of three types of levels (or building blocks): convolution, clustering, and fully connected levels. The first two, convolution and grouping, perform feature extraction, while the third, a fully connected layer, maps the extracted features into the final output, such as classification. A level of convolution plays a key role in CNN, which is made up of a stack of mathematical operations, such as convolution, a specialized type of linear operation. In digital images, pixel values are stored in a two-dimensional (2D) grid, i.e., a matrix of numbers (Fig. 2) and a small parameter grid called a kernel, an optimizable feature extractor, is applied to every position of the image, which makes CNNs very efficient for image processing, because a feature can appear anywhere in the image. one level feeds its output into the next level, the extracted characteristics can become hierarchically and progressively more complex. The process of optimizing parameters such as kernels is called learning, which is done in a way that minimizes the difference between the output and base truth labels through an optimization algorithm called backpropagation and gradient descent, among others.[2]

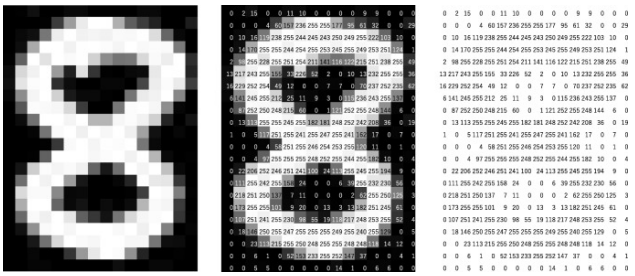


Fig. 1. A computer sees an image as an array of numbers. The matrix on the right includes numbers ranging from 0 to 255, each of which corresponds to the brightness of a pixel in the left picture. In the center of the image, both are superimposed.

### *B. Image Editing*

This is a common method of editing digital images using graphic software tools. It can be used in many different fields. It generally can be divided into two categories: pixel editing and parametric editing. Pixel editing aims to change the image by taking advantage of its pixels; parametric editing is meant to modify the image without changing its underlying structure.

### *C. Image restoration*

It is a method of recovering a degraded image from a reduced image, such as a blurry image with noise. These techniques also provide solutions for deblurring blurred images at low computational costs.

### *D. Independent Component Analysis*

In this technique, a multivariate signal can be subdivided into components in a computationally efficient manner by using Independent Component Analysis (ICA). It is a statistical and mathematical technique for uncovering hidden factors from a set of random variables, measurements, or signals. Multivariate variables are used to derive generative models.

### *E. Anisotropic Diffusion,*

which is often known as Perona-Malik Diffusion, makes it possible to reduce image noise without having to remove important parts of the image

### *F. Linear Filtering*

The linear algorithm is another technique for digital image processing, in which time-varying signals are processed and a linear output is generated.

### *G. Artificial neural networks (ANNs), often known as neural networks (NNs)*

These networks are designed to recognize patterns from data, using algorithms to interpret the data. Their decisions are based on this data, which can be sound, images, text, and...

### H. Principal Components Analysis (PCA)

It is a popular dimensionality reduction method used in Machine Learning applications. PCA is an image processing technique that can be used to extract features. By applying some sort of transformation to a large set of variables, PCA condenses information from them into fewer variables. In this way, linearly correlated variables are transformed into uncorrelated ones. We can compress information by reducing the redundancy of information, and we can do this through correlation. Partial Differential Equations**,** which also is dealing with effectively de-noising images.

### I. Hidden Markov Models

The "Markov Chain" or "Markov Process" is a model for displaying a sequence of random variables in which the probability of the occurrence of each event depends only on the previous one. The possibility of happening in such models is related to the previous time and the rest of the cases without any relation to the probability of them. Markov's hidden model is like a Markov process, except that the state space is unknown here. In this way, we cannot determine whether the situation corresponds to the events, and each state has an output. We will guess the sequence of process values based on the output.

### J. Wavelets

We apply Wavelet transform twice in accordance with the JPEG-2000 standard to transform images: first on the columns, then on the rows. Wavelet transform is especially useful when transforming images. Following this, we possibly recursively transform each sub-band separately after deinterleaving the image matrix.

### K. Self-organizing Maps

Self-organizing Maps are computer-based techniques to classify images according to several categories. One of the learning models will classify the units based on similarities between certain patterns and corresponding areas in the image.

### L. Pixelation

When an image becomes pixelized, we can distinguish individual pixels within an image, which makes the image appear fake or over-digitized. The human eye can distinguish individual pixels among an image when it becomes pixelized.

### M. Partial Differential Equations

This technique is for reducing the noise. In the partial differential equation method, the image is modeled according to the partial differential equation, then the image is changed based on the partial differential equation, and the effect is achieved.

## V. Conclusion

This paper outlines the widely used applications and methods of Image Processing. It also deep dives into the algorithms or techniques best used currently for Image Processing and Image Recognition after surveying multiple papers and tallying accuracy results of algorithms. We can also conclude that specific applications for image processing e.g., Image Recognition, have specific techniques that work much better and provide significantly precise results than other techniques.


## Acknowledgment

We would like to appreciate Dr. Safaa Bedawi whose guidance was very helpful in researching existing Image Processing Applications and Techniques. We are also grateful to people pioneering the research in Image Processing to give us a chance to explore the latest technology and best methods.


## References


[1] P.L, Chithra, and P, Bhavani, A Study on Various Image Processing Techniques International Journal of Emerging Technology and Innovative Engineering Volume 5, Issue 5, May 2019.

[2] Rikiya Yamashita, Mizuho Nishio, Richard Kinh Gian Do, and Kaori Togashi, Convolutional neural networks: an overview and application in radiology. Insights into imaging, Volume 9, Issue 4, 2018.

[3] K. Chen, "Introduction to variational image-processing models and applications", International Journal of Computer Mathematics, vol. 90, no. 1, pp. 1-8, 2013.

[4] Vijay Kumar and Priyanka Gupta, "Importance of Statistical Measures in Digital Image Processing", International Journal of Emerging Technology and Advanced Engineering, Volume 2, Issue 8, August 2012.

[5] B. Chitradevi and P.Srimathi, "An Overview on Image Processing Techniques", International Journal of Innovative Research in Computer and Communication Engineering, Vol. 2, Issue 11, November 2014.

[6] Shreyas Fadnavis, "Image Interpolation Techniques in Digital Image Processing: An Overview", International Journal of Engineering Research and Applications, Volume 4, Issue 10, October 2014.

[7] Pramod Kumar Pandey, Yaduvir Singh, and Sweta Tripathi, "Image Processing using Principle Component Analysis", International Journal of Computer Applications, Volume 15, Issue 4, February 2011.

[8] Basavaprasad B, Ravi M, "A Study on the Importance of Image Processing and its Applications", International Journal of Research in Engineering and Technology, Volume 3, Issue 3, May 2014.

[9] S.Anila and Dr.N.Devarajan, "Preprocessing Technique for Face Recognition Applications under Varying illumination Conditions", Global Journal of Computer Science and Technology, Volume 12, Issue 11, 2012.

[10] V. Wiley and T. Lucas, "Computer Vision and Image Processing: A Paper Review", International Journal of Artificial Intelligence Research, vol. 2, no. 1, p. 22, 2018.