

## Image Processing in Artificial Intelligence

Shahzeb Hussain<sup>1</sup>, Prayas Dixit<sup>2</sup>, Md. Shaayan Hussain<sup>3</sup>

<sup>1</sup>Infosys Limited, Pune, Maharashtra, India

<sup>2</sup>Infosys Limited, Pune, Maharashtra, India

<sup>3</sup>Tata Consultancy Services, Chennai, Tamilnadu, India

### ABSTRACT

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Machines can learn to elucidate images the same way our brains do and analyse those images much more thoroughly than we can. When applied to Image Processing, Artificial Intelligence (AI) can propel face recognition and security functionality in public places, detecting and recognizing intruders, objects, and patterns in live images and videos, etc. Image processing technology focuses on the development of data extraction methods applied to the statistical classification of visual imagery. In classical image processing systems, an image is pre-processed to remove noise (denoising), segmented to produce close object boundaries, analysed to extract a representative feature, and compared to the ideal object feature vectors by a classifier to decide the nearest object classification and its associated level. In this paper, we discuss about digital image processing and the role of AI in it.

**Keywords** : Image Processing, Artificial Intelligence, Digital Image, Data Extraction

### I. INTRODUCTION

Basically, image processing is the manipulation of an image in order to enhance it or extract information from it. There are two methods of image processing:

- **Analog image processing:** It is used for processing physical photographs, printouts, and other hard copies of images.
- **Digital image processing:** It is used for manipulating digital images with the help of computer algorithms.

In both cases, we take the input as an image. For analog image processing, the output is always in an

image form. For digital image processing, however, the output may be an image or some data associated with that image, such as features, bounding boxes, characteristics, or masks. In today's world, image processing is widely used in biometrics, gaming, medical visualization, surveillance, self-driving vehicles, law enforcement, and other fields <sup>[1]</sup>.

Here are some of the main objectives of image processing:

- **Visualization** — Represents processed data in an understandable and more meaningful way, giving visual form to objects that aren't visible, for instance.

- **Image sharpening and restoration** — Improves and enhances the quality of processed images.
- **Image retrieval** — Helps in the searching of images.
- **Object measurement** — Measures objects in an image.
- **Pattern recognition** — Distinguishes and classifies objects in an image, identifies their positions, and understands the scene.

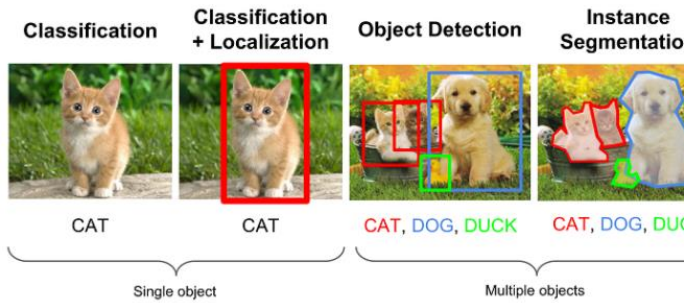


Figure 1: Examples of pattern and object recognition operations

There are eight key phases included in Image Processing:

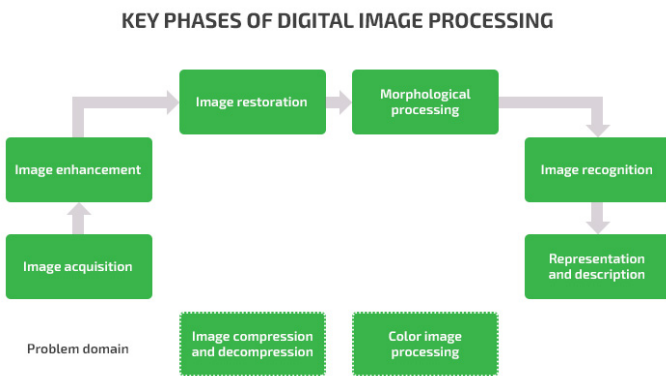


Figure 2: Key Phases of Digital Image Processing

Now we will look closer at each of these phases.

1) **Image acquisition** – It is the process of capturing an image with a sensor (e.g. a camera) and converting it into a manageable entity (e.g. a digital image file). One popular image acquisition method is scraping [2].

2) **Image enhancement** – This phase enhances the quality of the captured image to extract hidden information from it for further processing.

3) **Image restoration** – This also improves the quality of an image by removing possible corruptions in order to get a clearer version. This process is based mostly on probability and mathematical models and can be used to get rid of noise, blur, missing pixels, watermarks, camera misfocus, and other corruptions that may affect the training of a neural network.



Figure 3: An example of an image with a watermark

4) **Color image processing** – It includes the processing of colored images and different color spaces. Depending on the image type, we can talk about pseudocolor processing or RGB processing.

5) **Image compression and decompression** – This method allows changing of the size and resolution of an image. Compression is used for reducing the resolution and size, while decompression is for restoring an image to its original size and resolution.

These techniques often come into practice during the image augmentation process. When we have less data, we can extend our dataset with slightly augmented images. In this way, we can improve the way our neural network model generalizes data and make sure it provides high-quality results [3].

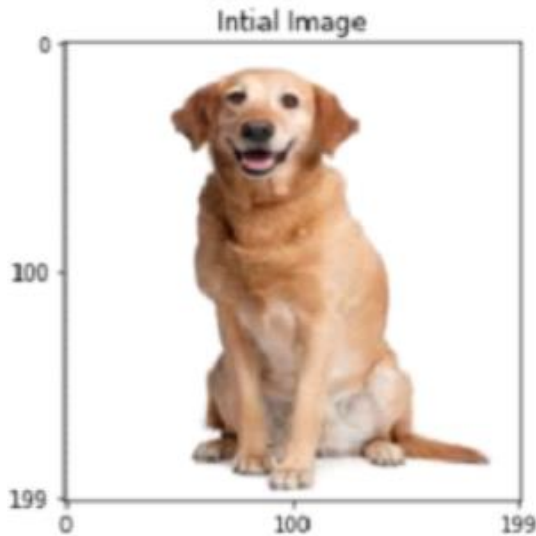


Figure 4a: Initial image

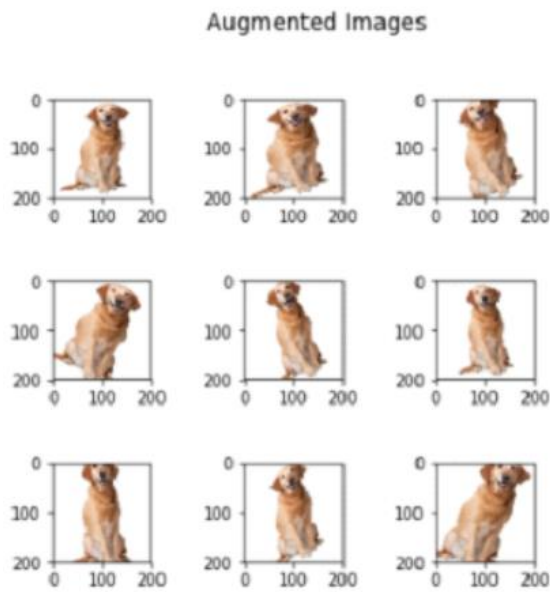


Figure 4b: Augmented images

6) **Morphological processing** – This method describes the shape and structure of the objects in an image. It can be used when creating datasets for training AI models. In particular, morphological analysis and processing can be applied at the stage where we want to describe what we need our AI model to detect or recognize.

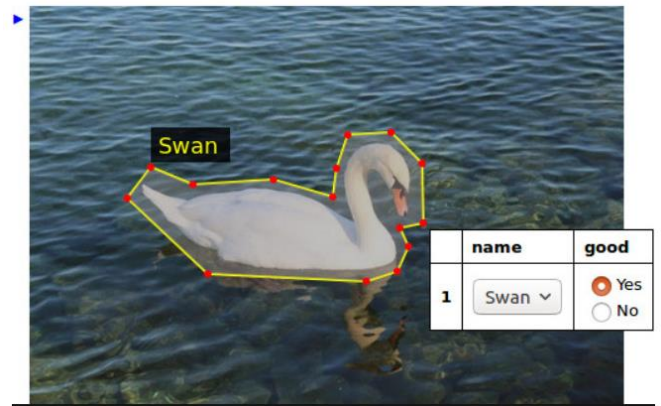


Figure 5: An example of the annotation process of morphological analysis

7) **Image recognition** – This is the process of recognising specific features of particular objects in an image. Image recognition with AI often utilises such techniques as object detection, object recognition, and segmentation. This is where AI solutions truly flourish. Once we complete these entire image processing phases, we are ready to build, train, and test an actual AI solution. The process of deep learning development includes a full cycle of operations from data acquisition to incorporating the developed AI model into the end system [4].

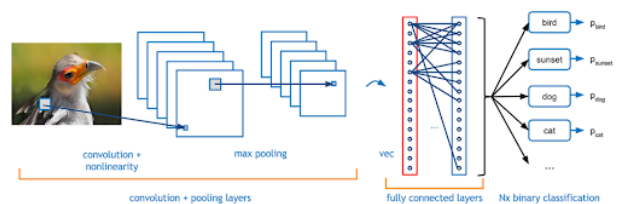


Figure 6: Image recognition with a CNN

8) **Representation and description** – It is the process of visualizing and describing processed images. The raw output of an AI system looks like an array of numbers and values that represent the data the AI model was trained to produce. A deep neural network usually doesn't produce any output data representations. With the help of special visualization tools, these arrays of numbers can be turned into readable images suitable for further analysis.

The use of Artificial Intelligence and Machine Learning amplifies both the speed of data processing and the quality of the final result. With the aid of AI platforms, we can successfully achieve such complex tasks as face recognition, object detection, and text recognition. But, in order to get high-quality results, we need to pick the right tools and methods [5].

## II. IMAGE PROCESSING METHODS, TECHNIQUES, AND TOOLS

Most images taken with regular sensors (e.g. camera) require pre-processing, as they can contain too much noise. Filtering and edge detection techniques are two of the most common methods for processing digital images [6].

- **Filtering** – This method is used for improving and modifying the input image. With the help of different filters, we can emphasize or remove certain features in an image, reduce image noise, and so on. Popular filtering techniques include linear filtering, Wiener filtering, and median filtering.
- **Edge detection** – It uses filters for data extraction and image segmentation. This method helps to find meaningful edges of objects in processed images by detecting discontinuities in brightness. Roberts edge detection, Sobel edge detection, and Canny edge detection are among the most popular edge detection techniques.

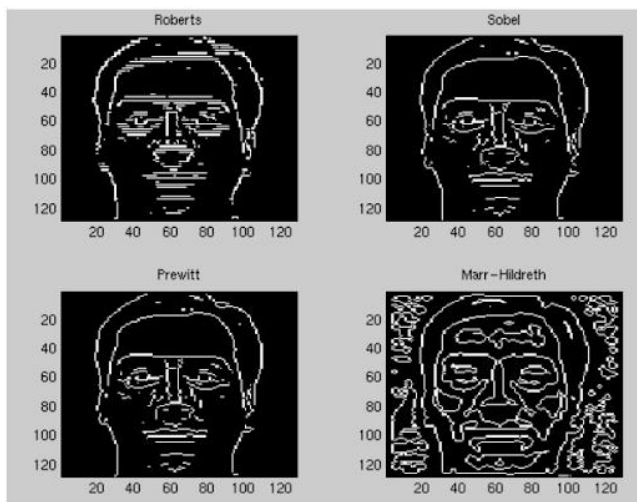


Figure 7: Examples of edge detection

To make it easier to use these methodologies as well as to implement AI-based image processing functionalities in our product, we can use specific libraries and frameworks. In the next section, we take a closer look at some of the most popular open-source libraries for accomplishing different image processing tasks with the help of AI algorithms.

### A. OpenCV

The Open Source Computer Vision Library (OpenCV) is a popular library that provides a number of computer and machine learning algorithms and functions for composing and supporting those algorithms. The library comes with Python, C++, and Java interfaces and supports all popular desktop and mobile operating systems. It includes various modules, such as a machine learning module, an image processing module, and an object detection module. Using this library, we can acquire, compress, enhance, restore, and extract data from images.

### B. Visualisation Library

Visualization Library is C++ middleware for 2D and 3D applications established on the Open Graphics Library. This toolkit allows building portable and high-performance applications for Windows, Linux, and Mac OS systems. It is easy and comfortable to work with.

### C. VGG Image Annotator

VGG Image Annotator (VIA) is a web-based application for object annotation. It can be installed in a web browser and can be used for annotating detected objects in images, and video records. VIA doesn't require additional setup or installation and can be used with any modern browser.

## III. MACHINE LEARNING FRAMEWORKS AND IMAGE PROCESSING PLATFORMS

If we want to move beyond using simple AI algorithms, we can build custom deep learning

models for image processing. This will make the development a bit faster and easier. We can also use special platforms and frameworks. Now we will take a look at some of the most popular ones:

#### A. *TensorFlow*

Google's TensorFlow is a popular open-source framework with support of machine learning and deep learning. Using TensorFlow, we can create and train custom deep learning models. This framework also provides a set of libraries that can be used in image processing and computer vision projects.

#### B. *PyTorch*

PyTorch is an open-source deep learning framework created by the Facebook AI Research lab (FAIR). This framework has Python, C++, and Java interfaces. It is used for building computer vision and natural language processing applications.

#### C. *MATLAB Image Processing Toolbox*

MATLAB is an abbreviation for matrix laboratory. It's a popular platform for solving scientific and mathematical problems. It has an Image Processing Toolbox (IPT) that provides multiple algorithms and workflow applications for processing, visualizing, and analyzing images. MATLAB IPT allows automating common image processing workflows. This toolbox can be used for noise reduction, image segmentation, image enhancement, 3D image processing, and other tasks. A lot of IPT functions support C/C++ code generation, so they can be utilised for deploying embedded vision systems and desktop prototyping [7].

#### D. *Microsoft Computer Vision*

Computer Vision is a cloud-based service provided by Microsoft that provides access to advanced algorithms for image processing and data extraction. It allows to:

- Moderate image content
- Extract text from images
- Inspect visual attributes and characteristics of an image

#### E. *Google Cloud Vision*

Cloud Vision is a part of the Google Cloud platform and provides a set of image processing features. It offers an API for integrating such features as object localization, image labelling and classification, and object recognition. Cloud Vision uses pre-trained machine learning models and create and train custom machine learning models for solving different image processing tasks [8].

#### F. *Google Colaboratory (Colab)*

Google Colaboratory, known as Colab, is a free cloud service that can be used for developing deep learning applications from scratch. Colab makes it easier to use popular libraries such as Keras, OpenCV, and TensorFlow. Colab provides free GPU resources as well. In addition to different libraries, frameworks, and platforms, a large database of images is also required to train and test our model.

There are several open databases that contain millions of tagged images that can be utilised for training our custom machine learning applications and algorithms. ImageNet and Pascal VOC are the most popular.

## IV. CONCLUSION

With the help of deep learning algorithms and neural networks, we can teach machines to see and interpret images in the way required for a particular task. Image processing, itself has brought benefits in different areas of technology especially to analyze images to obtain the necessary information. Progress in the implementation of AI-based image processing is impressive and opens a wide range of opportunities in fields from medicine and agriculture to retail and law enforcement, geographical remote sensing, robotics, computer and human communication, healthcare, and satellite communication.

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