

Open Source Platforms and Recognition for Image Processing

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Abstract

An algorithm is executed on digital images using a digital computer as part of digital image processing. Digital image processing offers various benefits over analogue image processing. To minimize problems like noise and distortion accumulation, a wider choice of algorithms may be used to analyses input data. As a multidimensional system, digital image processing may be regarded as a two-dimensional system. All three factors—the advancements in computers and mathematics (especially discrete mathematics theory and its refinement), as well as the growing need for digital image processing in environmental, agricultural, and military fields—have led to the expansion of digital image processing.

Keywords: Image Processing Frameworks, Open Source Platforms, Open Source Image Processing

Introduction

The 1960s saw the development of many methods for digital image processing, or digital image processing, at places including Bell Laboratories, Jet Propulsion Laboratory, MIT, and the University of Maryland, among others [1].

Early image processing was aimed at improving image quality. The idea was to have a bigger visual effect on the people around you. Images of poor quality are sent into image processing, and the outcome is an improvement in image quality. Some of the most common image processing methods include image enhancement, restoration, encoding, and compression. There is a reason why NASA's Jet Propulsion Laboratory is known as "JPL" (JPL). Geometric correction, gradation transformation, and noise reduction were used to adjust images from the Space Detector Ranger 7 broadcast back in 1964, taking into account the sun's location and the lunar environment. The successful mapping of the moon's surface by a computer has been an amazing accomplishment. There were over 100,000 imagegraphs taken by the spacecraft that were subsequently used to generate a topographic map, colour map, and panoramic mosaic. These findings were awe-inspiring and laid the groundwork for a manned lunar landing.



Figure 1: Benchmark Image of Lena for Image Processing.

However, owing to the absence of contemporary computer technology, the cost of processing was rather high in those days. Digital image processing began to gain traction in the 1970s, as computers and specialized gear became more widely available. As a consequence, images may be processed in real time for specialized activities like converting television standards. General-purpose computers have largely supplanted specialized hardware in all but the most labor-intensive and specialized of jobs.. Because of the high-speed computers and signal processors available at the time, digital image processing has been the most used kind of image processing [3].

Sensor and device-based image capture

At Bell Labs, Mohamed M. Atalla and Dawon Kahng devised the MOSFET (MOS field-effect transistor) in 1959, which has served as the basis for contemporary image sensors.

CMOS image sensors were created in reaction to the development of charge-coupled devices (CCDs).

In 1969, Willard S. Boyle and George E. Smith invented the charge-coupled device at Bell Labs.

While researching MOS technology, they realized that an electric charge could be used as a magnetic bubble's equivalent and could be stored on a tiny MOS capacitor. MOS capacitors in a row may be charged sequentially by attaching a suitable voltage to each MOS capacitor in the row. First digital video cameras for television transmission were equipped with a semiconductor circuit known as the CCD later on.

An active-pixel sensor (APS) developed by Japanese Olympus for digital cameras dates back to the 1980s. Scaling down MOSFET device manufacturing to micron and subsequently sub-microscopic levels enabled this to happen. In 1985, the Olympus NMOS APS was developed by Tsutomu Nakamura and his team. The first CMOS active-pixel sensor was developed by Eric Fossum's team at NASA's Jet Propulsion Laboratory in 1993. In the year 2007, CMOS sensors have surpassed CCD sensors in the market share stakes for digital cameras.

The discrete cosine transform (DCT), first proposed by Nasir Ahmed in 1972, and was a major achievement in digital image reduction. JPEG was created in 1992 by the Joint Imagegraphic Experts Group, which used DCT compression. Thus, JPEG is the most widely used image file format on the internet, helping to reduce the size of images. In 2015, the DCT compression technology created many billion JPEG images each day, making digital imagegraphs and digital imagegraphs conceivable.

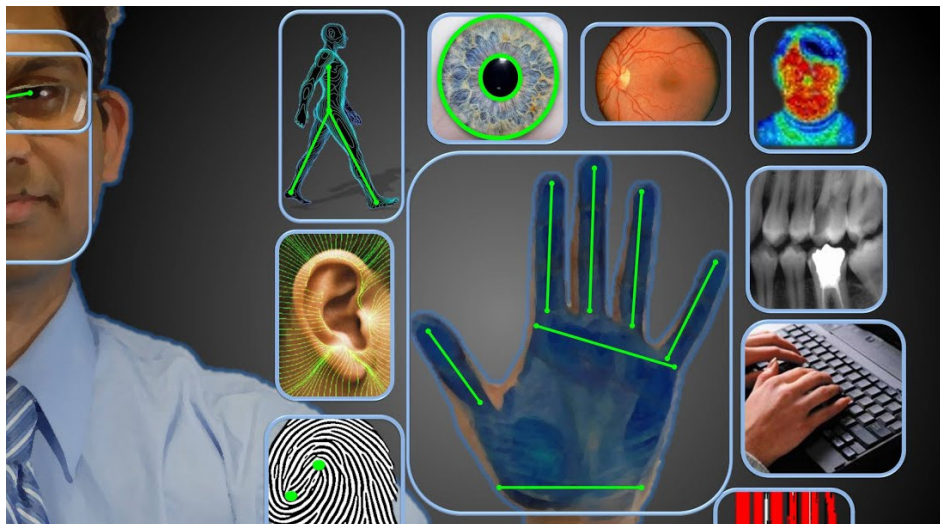


Figure 2: Image Analytics.

Digital Signal Processing Device (DSP)

New electronic signal processing techniques were ushered in by the widespread adoption of MOS in the 1970s.

DSP chips were the first single-chip digital signal processing (DSP) chips to be developed in late 1970s, whereas the first single-chip microprocessors were developed in the early 1970s.

Thus, DSP chips have become more prevalent in digital image processing equipment.

As the discrete cosine transform (DCT) algorithm continues to be widely utilized in DSP chips, several companies are developing their own. It is typical for DCTs to be used in a wide range of applications from video and audio coding to multiplexing to control signals to signalling to analog-to-digital conversion and colour formats like YUV444 and YUV411. DCTs can be used for a wide range of tasks, including the inverse conversion between YIQ, YUV, and RGB colour formats (for display purposes), motion estimation, motion compensation, inter-frame prediction, quantization, perceptual weighting, entropy encoding, variable encoding, and the generation of motion velocities and vectors. DCTs are often used in HDTV encoder/decoder chips [5].

This technology for head diagnostics was developed in 1972 by British engineer EMI Housfield, who is known as the inventor of CT (computer tomography). The CT nucleus technique, which utilizes a projection of a human head section, allows for the computer-assisted reconstruction of cross-sectional images. In 1975, EMI built a CT scanner for the full body, allowing tomograms to clearly show distinct parts of the human body. The Nobel Prize in Physiology or Medicine in 1979 went to this diagnostic procedure. A digital image

processing technique for medical applications was recognized in 1994 by the Space Foundation Space Technology Hall of Fame.

Key Tasks

Using digital image processing, it is feasible to develop approaches that would be impossible with analogue technology since it allows for the employment of considerably more complicated algorithms [6].

Image processing is a real application of, and a practical technology built on, the principles of digital imagegraphy

Classification and Extracting features

The following are some of the methods employed in digital image processing:

- Diffusion with anisotropy
- Invisible Markov chains
- Editing images
- Image retouching
- Analyzing the components on their own
- Using a linear filter
- Neural Networks
- Differential and integral equations
- Pixilation
- Similarity in feature points
- Analysis of the principal components
- Maps that are self-organizing
- Wavelets

Image processing is a technique for applying various operations to a image in order to improve its quality or extract relevant data from it. This sort of signal processing takes an image as input and outputs either an image or image characteristics/features. The field of image processing is one that is exploding right now. Additionally, it is a major research focus in engineering and computer science.

The three main phases in image processing are as follows:

Analyzing and altering the image once it is imported via image acquisition tools; producing a new image or report depending on the results of the analysis.

Analogue and digital image processing are the two main forms of image processing.

This type of image processing is best suited for hard copies such as prints and images.

When interpreting images with the use of these visual approaches, image analysts apply a variety of theoretical foundations. Computers can be used to manipulate digital imagegraphs using digital image processing techniques. Pre-processing, augmentation, and presentation, or information extraction, are the three main processes that all sorts of data must go through when employing digital technology [7].

Quantification by use of sampling

A function $f(x,y)$ must be digitalized before it may be used for digital processing. A frame grabber or digitizer is often used to sample and quantize an analogue video feed. That's why it's vital to digitise raw data before creating a digital image. Both of these actions must be carried out in order to finish the procedure.

A image's spatial resolution is largely determined by its sampling rate and quantization level when it is digitised. The magnitude of a sampled image is represented as a digital value in image processing. When the continuous values of an image function are converted to their digital equivalents, this is known as quantization [8].

The number of quantization levels in the image should be as large as possible in order for humans to be able to detect even the smallest shade fluctuations. False outlines infect an image quantized with inadequate brightness levels.

In order to apply an image's affine matrix accurately, the intensity of each pixel must be recorded in an image matrix. Each image's location may therefore be represented as a vector that shows the image matrix's coordinates for $[x, y]$ for each pixel. An affine-transformation matrix may be used to find the place in the final image where a pixel value will be copied from using this approach.

To accommodate translational changes, three-dimensional homogeneous coordinates must be used. If $[x, y, 1]$ is set to a non-zero constant, it becomes the new coordinate for the third dimension. A 3 by 3 matrix may be used to multiply the coordinate vector and perform translation shifts. Because of the existence of the third dimension, which is represented by the constant 1, translation is feasible.

To combine many affine transformations into one, you may simply multiply the matrixes in the sequence in which they were carried out, resulting in one affine transformation. A single matrix must be applied to the $[x, y, 1]$ vector in order to get the same effect as all the transformations done sequentially. Thus, it is feasible to reduce an entire collection of transforms to only one transform matrix by using this method of decomposition.

Coordinates may only be rotated around the origin in two-dimensional space, for example (0, 0). On the other hand, 3D homogeneous coordinates may be used to first translate any point to (0, 0), rotate it, and then translate the origin (0, 0) to the original point (the opposite of the first translation). The image may be rotated in any direction by combining the three affine transformations [9][10].

Applications

Digital image processing (DIP) has a wide variety of applications and has an impact on practically every technological industry, therefore we'll concentrate on just a few of them here. It's not enough to change the camera's spatial resolution when it comes to digital image processing. It's not only about brightening the image or making it clearer. A lot more goes into it.

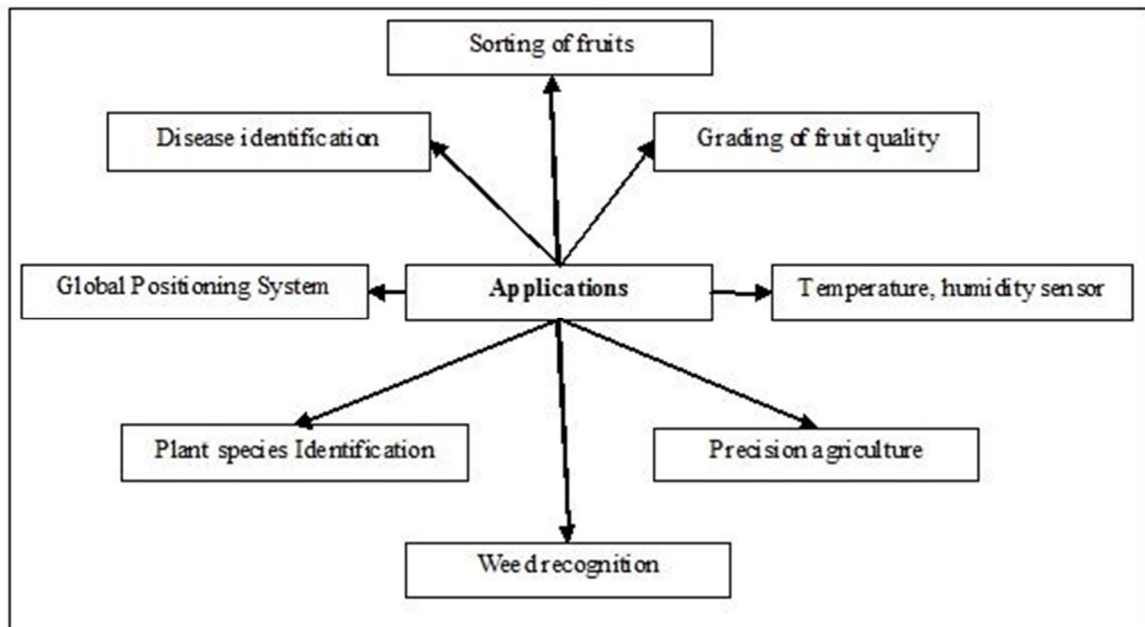


Figure 3: Applications of Image Processing.

Electromagnetic waves may be likened to a stream of particles travelling at the speed of light. Each atom has a tremendous amount of energy stored inside of it. A imagine is the name given to this collection of energy.

Only in this electromagnetic spectrum can we see the visible spectrum. There are seven main colours that make up the majority of the visible spectrum (VIBGOYR). VIBGOYR stands for violet, indigo, blue, green, orange, yellow, and red.

This doesn't mean that there aren't other things on the spectrum. As a result, we were only able to observe what was in the region that could be seen. Whereas the human eye cannot see fine details, a camera can. Take gamma rays, for example, or x rays, for example. As a consequence, all of the analyses are performed using digital image processing [11][12].

Since X-rays have been extensively used in the medical field, the answer to this question is straightforward. Nuclear medicine and astronomy are only two fields that might benefit from Gamma ray analysis. All of the other parts of the electromagnetic spectrum are the same in this regard as well.

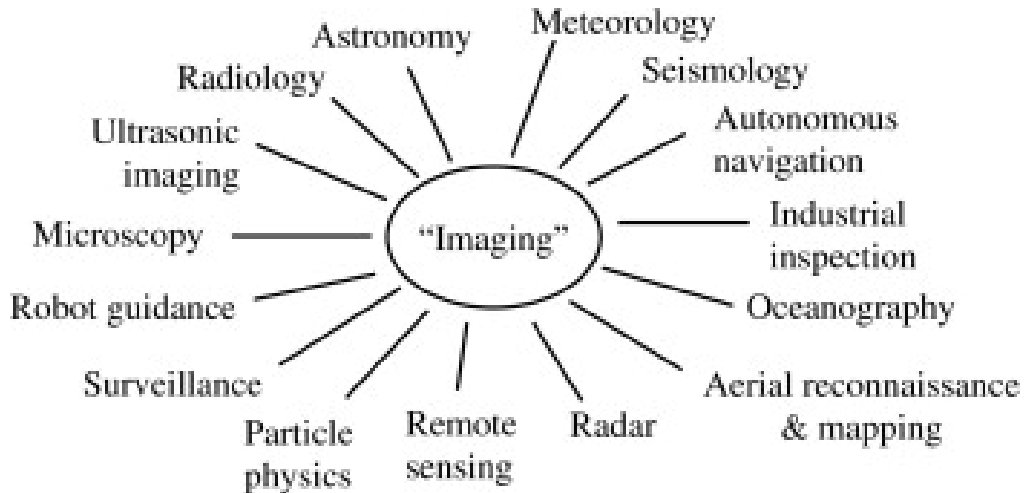


Figure 4 : Aspects with Imaging

The following are a few of the most common applications for digital image processing.

- Enhancement of the visual quality of an image
- Medical Domain
- Infrared spectroscopy
- Encoding and transmission
- Vision from a robot or a machine
- processing of colour
- Detection of recurring patterns
- Video Processing
- Imagery at a Closer Range
 - And many Others

Enhancement of the visual quality of an image

In this context, "image sharpening and restoration" refers to enhancing or enhancing images acquired by current cameras in order to produce a better image or accomplish a desired outcome. It means to carry out the normal functions of Imageshop [13][14].

This comprises zooming, blurring, sharpening, converting grayscale to colour, identifying edges and the other way around, Image retrieval, and Image recognition.

A few examples include:

- Einstein's zoomed-in imagegraph.
- Image of Albert Einstein that has been distorted
- A shaky, blurry image
- Sharp Edges
- borders of the medical field

DIP is frequently used in the medical industry for the following purposes:

- X-ray imaging using gamma rays
- PET (positron emission tomography) scan
- Infrared Scanning
- CT scans in the medical field
- Imaging in the ultraviolet (UV)

Using a satellite or a very high vantage point, scientists may look at the surface of the Earth and extract data about it through the process of remote sensing. In remote sensing, digital image processing can be used to detect infrastructure damage caused by an earthquake [15][16]. Even if substantial damages are the emphasis, it takes longer to

grasp harm. It is impossible to inspect the whole region affected by an earthquake with the naked eye in order to evaluate the extent of damage. In any case, it is a highly time-consuming and demanding process. So digital image processing provides a solution to this problem. An aerial imagegraph of the quake-damaged region is taken and examined to determine the extent of the damage.

Encoding and transmission

A underwater cable carried the first image ever sent across the wire, from London to New York. Here's a look at the image that was sent. It took three hours for the imagegraph to travel from one location to the next. As an example, consider the possibility of seeing real-time video feeds or live cctv footage from one continent to another with only a few seconds of latency. A lot of effort has been put into this sector as well. This area focuses on both transmission and encoding, not only transmission. A wide variety of formats have been created for both high and low bandwidth encoding and streaming of imagegraphs.

Robotic Vision

In addition to the numerous difficulties robots confront today, one of the most pressing is how to improve the machines' eyesight. Achieve this by making the robot able to perceive objects, recognise them, and identify the obstacles. Much of the work has come from this area, and a new branch of computer vision has been established to continue the work in this area [17][18].

Detection of obstacles

By detecting different types of objects in a image and then estimating the distance between the robot and the hurdles, image processing has been used to do hurdle identification.

Detection of obstacles and Robotic line-follower

Line follower robots are the most common type of modern robots since they operate primarily by following a line. This aids a robot in following its intended course and carrying out certain duties. Image processing has also helped.

Processing of colour by robots

Processing of coloured images and the many colour spaces employed in colour processing are both included. Color models such as RGB, YCbCr, and HSV are examples. In addition, the transmission, storage, and encoding of these colour images must be investigated.

Detection of recurring patterns

Machine learning, image processing, and other domains are all used in pattern recognition (a branch of artificial intelligence). Images are first processed using image recognition and then machine learning is used to teach the system to recognise new patterns in the images. Computer-aided diagnosis, handwriting recognition, image identification, and other applications all make use of pattern recognition [19][20].

Video Processing

Nothing more than the rapid movement of images is what constitutes a video. Frames per minute and the quality of each frame determine the quality of the video. Noise reduction, detail improvement, motion detection, frame rate conversion, aspect ratio conversion, and colour space conversion are just a few of the video processing techniques that are utilised.

Retrieval of Medical Images

With the use of image processing, doctors have been able to develop more precise and effective medical treatments. For example, a nodule identification algorithm in breast scans can be used to detect breast cancer at an early stage. These applications require extensive testing and implementation before they can be accepted for use in the medical field [21].



Figure 4 : Medical Image Processing

Traffic Detection Systems

We employ a video image processing system (VIPS) for traffic sensors. In this case, there is an imaging system, a communication system, and a processing system all working together to capture images. On and off signals are generated by VIPS cameras as vehicles enter and depart a detection zone, respectively, and these signals may be used to track vehicles in real time. It is possible to set up detection zones for numerous lanes and utilise this information to monitor traffic at a specific station.

Additional features include automatic vehicle licence plate recording, vehicle type recognition, speed monitoring on highways, and a slew of other things.

Reconstruction of an image

An image's missing or corrupted elements can be recovered and filled in using image processing. Newer imagegraphs can be created utilising image processing systems that have been trained extensively on image datasets.

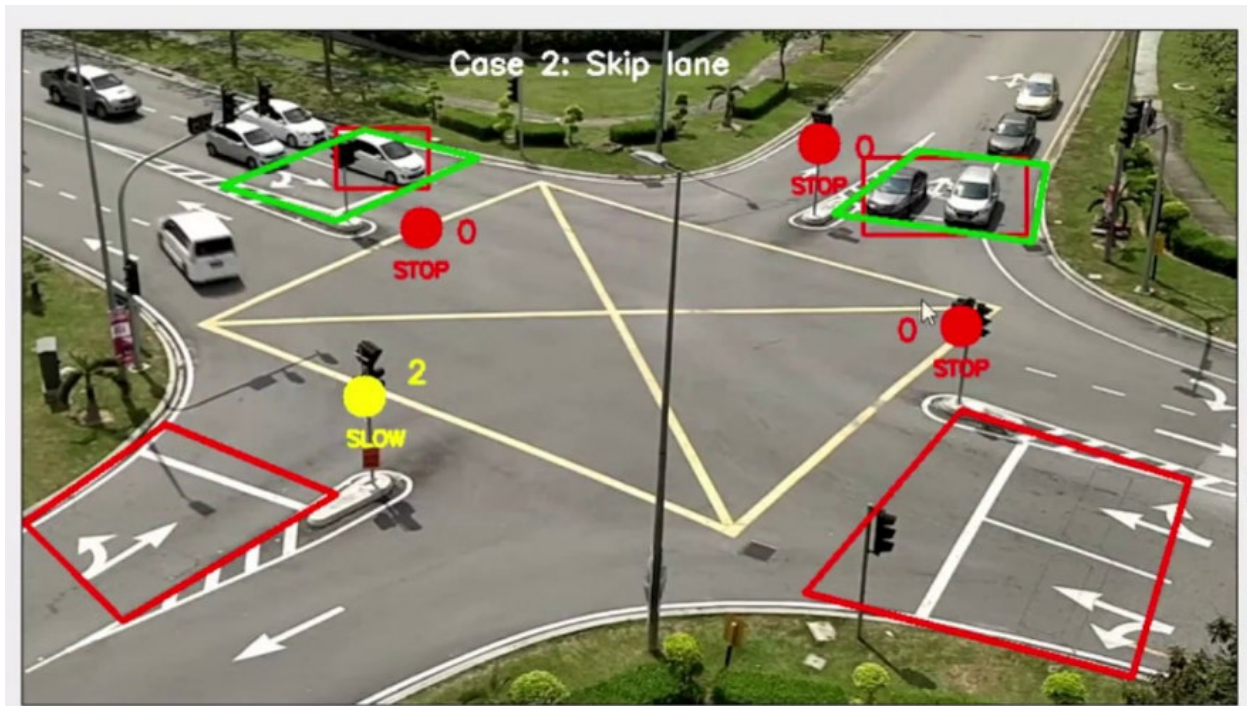


Figure 5 : Image Processing for Traffic Monitoring

Recognition of Human Faces

Face detection is one of the most widely used image processing applications nowadays. First, the machine learns how to identify certain elements of a human face, such the shape of a person's face, how far apart their eyes are from one another and so on. The machine will begin to accept any item in a image that resembles a human face after being taught

these traits. Security, biometrics, and even social networking applications' built-in filters all rely on face identification these days [22].

Free and Open Source Platforms and Frameworks for Image Processing

According to the definition of open source software, open source licences allow the programmer to be used, changed, and shared without restriction. If you want your license to be accepted by the Open Source Initiative (OSI), you must get it reviewed by the Open Source Initiative (OSI).

Here is a list of the many kinds of open source licences.

- In order for a piece of software to be called "Open Source," the following 10 conditions must be met:
- Redistribution Isn't Charged
- The program's source code must be available, and it must permit the program's dissemination.
- It is essential that derivative works and alterations can be made.
- integrity of the source code written by the author
- Affirmative Action for All Those Involved
- Non-Discrimination Regarding Applied Science and Technology
- License distribution should not be tied to a particular product; it should not restrict the use of other software; and it should be technology-neutral.

OpenCV

OpenCV is one of the most prominent open-source image processing services available. Free computer vision software that may be used for a variety of image processing tasks:

- Acquisition of an image
- The process of reducing and expanding the size of an image

- Enhancement and repair of images.
- Removing noise from an image
- Segmentation of a image
- Extraction of data, and much more

Numerous algorithms and routines, as well as specialised modules for image processing, are included in the collection. A deep learning module for creating and refining deep learning models has been added to the library as of latest version.

A machine learning model may then be applied utilising one of the available machine learning frameworks using this module's OpenCV capabilities.

TensorFlow, PyTorch, and Caffe are all supported by OpenCV as of this writing. Convolutional, deconvolutional, and recurrent neural networks are all included in the list of supported neural network types.

Programming languages supported by the library include C++, Java, Python and MATLAB interfaces [23].

TensorFlow

Google developed the machine learning framework TensorFlow, which is available as open source. As a Google Brain experiment, the project was initially launched. Even huge corporations like Dropbox and Intel are using TensorFlow to train their artificial intelligence systems.

In terms of image processing, TensorFlow is best suited for:

- Classification of images

- Recognition of images
- Segmentation of a image
- Translation from one image to another (pix2pix)
- Custom deep learning models and neural networks may be created and trained using TensorFlow's libraries. Support for Jupyter notebooks and a coding style guide are provided as part of the framework.

Python, Java, Rust and Go are among the languages supported by TensorFlow. Third-party bindings, such as those for Ruby, Scala, or PHP, can be installed, however this is not required.

Keras is a Python library for building deep learning models that is freely available. If you're just getting started with machine learning, this is a terrific option for you. It streamlines the process of creating a deep learning model from scratch. Fast and simple prototyping of neural networks may be done with Keras, which is intuitive to use.

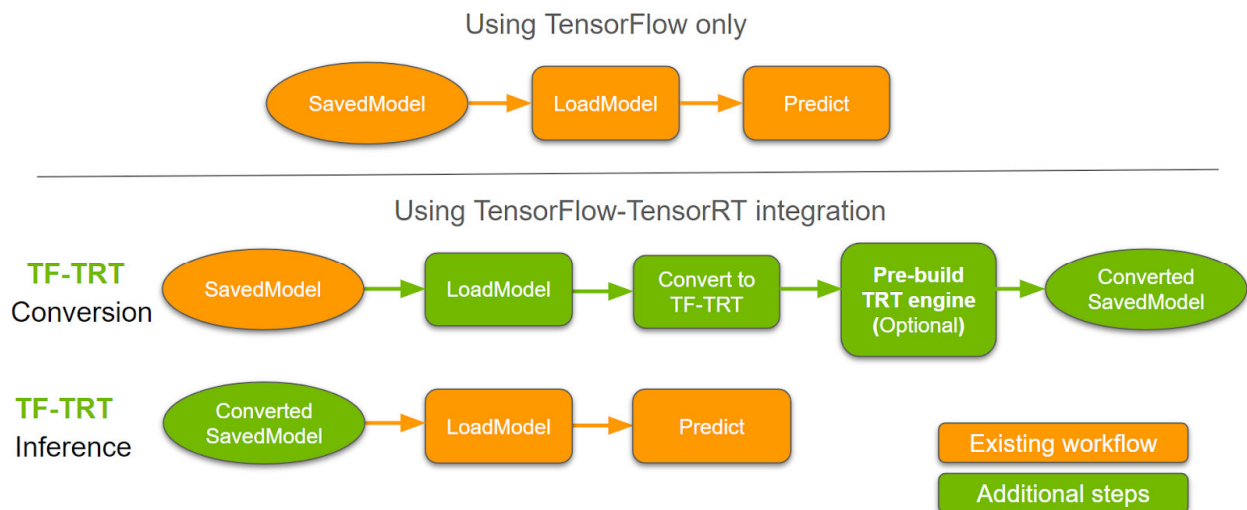


Figure 6: Tensorflow.

TensorFlow and the framework have been fully integrated with the library to date. You may create your deep learning model in Keras and then just include a particular TensorFlow feature or capability into this model [24] since Keras has a more user-friendly interface. There are a number of popular artificial intelligence frameworks that may be used in combination with Keras, including Microsoft Cognitive Toolkit and Theano. It is possible to build and train convolutional neural networks (CNNs) using the open-source Caffe Convolutional Architecture for Fast Feature Embedding (Caffe) framework. Classifying and segmenting images, and recognising objects, can all be done using Caffe [25]. Caffe may be utilised in Python scripts, despite being written in C++. The framework supports NVIDIA cuDNN and Intel MKL, two GPU-accelerated libraries. Pretrained deep learning models may be found in the Caffe Model Zoo database of the framework. It has just been announced that four BAIR-trained models have been released.

BAIR AlexNet

BAIR Other Caffe users have trained a lot of the models in the GoogLeNet Model Zoo as well. In terms of the supported neural networks, Caffe is best suited for convolutional (CNN) and feedforward networks. It's also not the greatest method for training recurrent neural networks. Caffe2, an open-source platform for developing and deploying deep learning models, was introduced by Facebook in 2017. Another prominent AI framework, PyTorch, was added to Caffe2 in 2018 [26]. In addition to C++ and Python APIs, Caffe2 supports all of the most prevalent operating systems on Earth.

Google Colab

Images may be processed in a variety of ways using Google's Collaborators. As a cloud service, you may still utilize Colab to construct your own deep learning apps from start using the framework. Colab. Image categorization, segmentation, and object identification

may all be accomplished using Colab. OpenCV, TensorFlow, and Keras are all prominent AI-based technologies that may be used with Google Colab. Use Jupyter Notebooks to share your expertise, insights, and best practises on AI-based apps with other developers. Unlike other similar services, Colab provides free use of both CPU and GPU acceleration. '

Conclusion

With the help of machine learning models and algorithms, developers may quickly and effectively include certain image processing capabilities into their products Creating a custom neural network or machine learning model is challenging and costly because of this. You may expedite the adoption of AI by using the open-source tools, libraries, and frameworks listed below. Image processing and analysis are essential if you want to get the most out of your images. With an open source architecture, a Java-based application such as ImageJ may be utilized to accomplish this aim because of its ability to simply create and modify processes. There are several online resources for ImageJ, including a support forum, regular updates, and in-person meetings. There is a large academic community that supports ImageJ. Being Java-based means that academics working on various operating systems may share executable code with ease because to ImageJ's platform neutrality. Like KNIME, you can utilize ImageJ with other open-source software. As an open source platform, OpenCV can be used for a variety of applications.

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