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A Review on Image Processing and Comparison of Classification Techniques

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Abstract- 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. Classification between objects is a fairly easy task for us, but it has proved to be a complex one for machines and therefore image classification has been an important task within the field of computer vision. Image classification refers to the labelling of images into one of a number of predefined classes [1][18]. There are potentially *n* number of classes in which a given image can be classified. manually checking and classifying images could be a tedious task especially when there are thousand of images and therefore it will be very useful if we could automate this entire process using computer vision. The advancements in the field of autonomous driving also serve as a great example of the use of image classification in the real-world. For example, we can build an image classification model that recognizes various objects, such as other vehicles, pedestrians, traffic lights, and signposts on the road.

Keywords — Image processing, Artificial Intelligence, Neural network

I. Introduction

Image Processing is a technology applied to images that helps us to process, analyze and extract useful information from them. It is used to convert an image into a digital aspect and perform certain functions on it, in order to get an enhanced image or extract other useful information from it. It is a type of signal time when the input is an image, such as a video frame or image and output can be an image or features associated with that image. Usually, the AWS Image Processing system includes treating images as two equal symbols while using the set methods. It is one of the fastest growing technologies today, with its use in various business sectors [2][3]. Graphic Design forms the core of the research space within the engineering and computer science industry as well. Image processing is a way by which an individual can enhance the quality of an image or gather alerting insights from an image and feed it to an algorithm to predict the later things.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 information extraction.

ML algorithms need a considerable amount of high-quality data to learn and predict highly accurate results. Hence, we'll have to make sure the images are well processed, annotated, and generic for ML image processing. This is where Computer Vision (CV) comes into the picture; it's a field concerning machines being able to understand the image data. Using CV, we can process, load, transform and manipulate images for building an ideal dataset for the machine learning algorithm[5].

II. STRUCTURE OF AN IMAGE CLASSIFICATION

Data Preprocessing→Feature Extraction→Classification→Post processing→Accuracy

A. *Image Pre processing*

Pre-processing is a common name for operations with images at the lowest level of abstraction both input and output are intensity images. Computers are able to perform computations on numbers and is unable to interpret images

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in the way that we do. We have to somehow convert the images to numbers for the computer to understand[18]. The aim of pre-processing is an improvement of the image data that suppresses unwilling distortions or enhances some image features important for further processing.

The aim of this process is to improve the image data(features) by suppressing unwanted distortions and enhancement of some important image features so that our computer vision models can benefit from this improved data to work on.

B. Detection of an object

Object detection is a computer vision technique that works to identify and locate objects within an image or video. Specifically, object detection draws bounding boxes around these detected objects, which allow us to locate where said objects are in (or how they move through) a given scene[7].

Object detection is commonly confused with image recognition, so before we proceed, it's important that we clarify the distinctions between them.

Image recognition assigns a label to an image. A picture of a dog receives the label "dog". A picture of two dogs, still receives the label "dog". Object detection, on the other hand, draws a box around each dog and labels the box "dog". The model predicts where each object is and what label should be applied. In that way, object detection provides more information about an image than recognition.

How does object detection work?

Deep learning-based object detection models typically have two parts. An **encoder** takes an image as input and runs it through a series of blocks and layers that learn to extract statistical features used to locate and label objects. Outputs from the encoder are then passed to a **decoder**, which predicts bounding boxes and labels for each object[15]. The simplest decoder is a pure regressor. The regressor is connected to the output of the encoder and predicts the location and size of each bounding box directly. The output of the model is the X, Y coordinate pair for the object and its extent in the image. Though simple, this type of model is limited. You need to specify the number of boxes ahead of time. If your image has two dogs, but your model was only designed to detect a single object, one will go unlabeled. However, if you know the number of objects you need to predict in each image ahead of time, pure regressor-based models may be a good option [8][9].

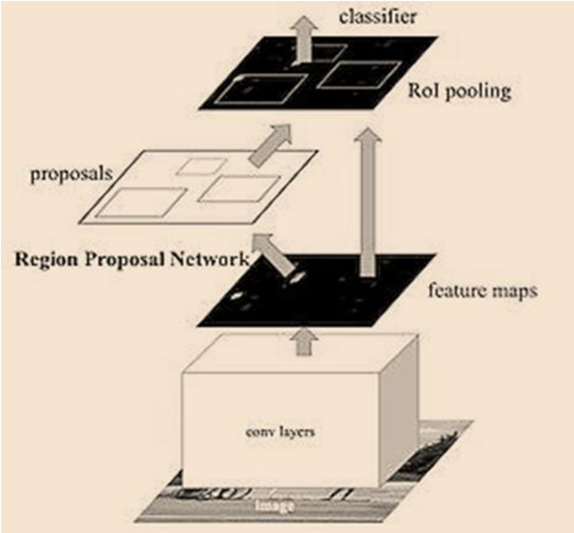

Fig.1. Object Detection

An extension of the regressor approach is **a** region proposal network**.** In this decoder, the model proposes regions of an image where it believes an object might reside. The pixels belonging to these regions are then fed into a classification subnetwork to determine a label (or reject the proposal). It then runs the pixels containing those regions through a classification network. The benefit of this method is a more accurate, flexible model that can propose arbitrary numbers of regions that may contain a bounding box. The added accuracy, though, comes at the cost of computational efficiency.

Single shot detectors (SSDs) seek a middle ground. Rather than using a subnetwork to propose regions, SSDs rely on a set of predetermined regions. A grid of anchor points is laid over the input image, and at each anchor point, boxes of multiple shapes and sizes serve as regions. For each box at each anchor point, the model outputs a prediction of whether or not an object exists within the region and modifications to the box's location and size to make it fit the object more closely[11][12]. Because there are multiple boxes at each anchor point and anchor points may be close together, SSDs produce many potential detections that overlap. Post-processing must be applied to SSD outputs in order to prune away most of these predictions and pick the best one.

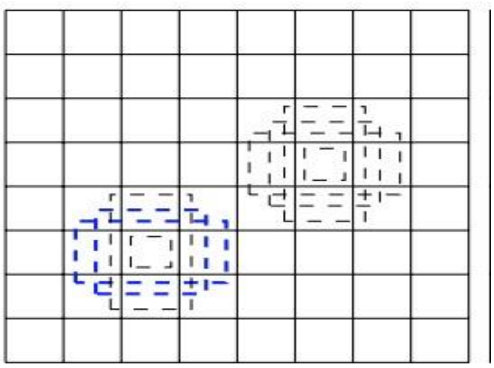

Fig.2. Object Detection

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Finally, a note on accuracy. Object detectors output the location and label for each object, but how do we know how well the model is doing? For an object's location, the most commonly-used metric is **intersection-over-union (IOU)**. Given two bounding boxes, we compute the area of the intersection and divide by the area of the union. This value ranges from 0 (no interaction) to 1 (perfectly overlapping). For labels, a simple "percent correct" can be used[13].

C. Feature extraction and Training

This is a crucial step wherein statistical or deep learning methods are used to identify the most interesting patterns of the image, features that might be unique to a particular class and that will, later on, help the model to differentiate between different classes. This process where the model learns the features from the dataset is called model training.

D. Classification of the object

This step categorizes detected objects into predefined classes by using a suitable classification technique that compares the image patterns with the target patterns.

III. IMAGE CLASSIFICATION TECHNIQUES

Some statistical machine learning classifiers like Support Vector Machine and Decision Tree and then move on to deep learning architectures like Convolutional Neural Networks.

To support their performance analysis, the results from an Image classification task used to differentiate lymphoblastic leukemia cells from non-lymphoblastic ones have been provided. The features have been extracted using a convolutional neural network, which will also be discussed as one of our classifiers[16]. This is because deep learning models have achieved state of the art results in the feature extraction process.

Different classifiers are then added on top of this feature extractor to classify images.

A. Support Vector Machines

It is a supervised machine learning algorithm used for both regression and classification problems. When used for classification purposes, it separates the classes using a linear boundary.

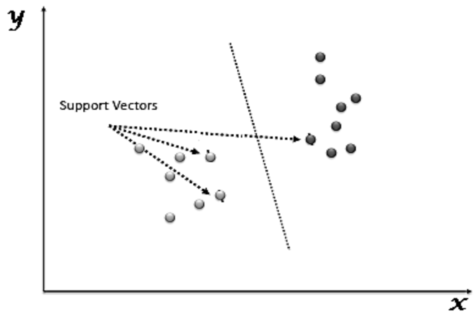

Fig.3. Support Vector Machine

It builds a hyper-plane or a set of hyper-planes in a high dimensional space and good separation between the two classes is achieved by the hyperplane that has the largest distance to the nearest training data point of any class. The real power of this algorithm depends on the kernel function being used.

B. Decision Trees

It is also a supervised machine learning algorithm, which at its core is the tree data structure only, using a couple of if/else statements on the features selected. Decision trees are based on a hierarchical rule-based method and permits the acceptance and rejection of class labels at each intermediary stage/level[17].

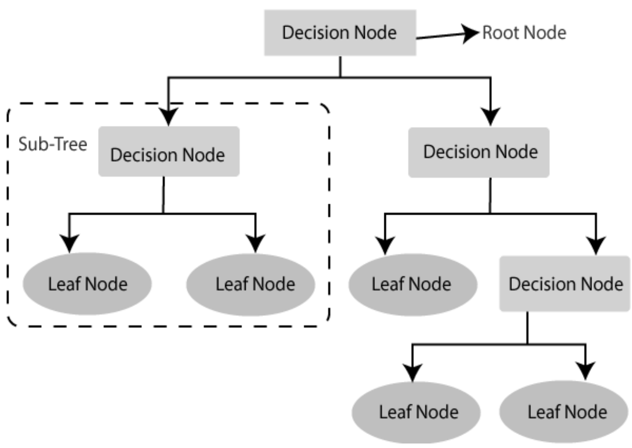

Fig.4. Decision Tree

This method consists of 3 parts:

Partitioning the nodes , Finding the terminal nodes and Allocation of the class label to terminal node

C. K Nearest Neighbor

The k-nearest neighbor is by far the most simple machine learning algorithm.
This algorithm simply relies on the distance between feature vectors and classifies unknown data points by finding the most common class among the k-closest examples. Here we can see there are two categories of images and that each of the data points within each respective category are grouped relatively close together in an n-dimensional space. In order to apply the k-nearest Neighbor classification, we need to

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define a distance metric or similarity function. Common choices include the Euclidean distance and Manhattan distance[9].

D. Random Forest Algorithm

Random forest is a supervised learning algorithm which is used for both classification as well as regression. As we know that a forest is made up of trees and more trees means more robust forest, similarly, random forest algorithm creates decision trees on data samples and then gets the prediction from each of them and finally selects the best solution by means of voting. It is an ensemble method which is better than a single decision tree because it reduces the over-fitting by averaging the result. The random forest is a classification algorithm consisting of many decision trees. It uses bagging and feature randomness when building each individual tree to try to create an uncorrelated forest of trees whose prediction by committee is more accurate than that of any individual tree.

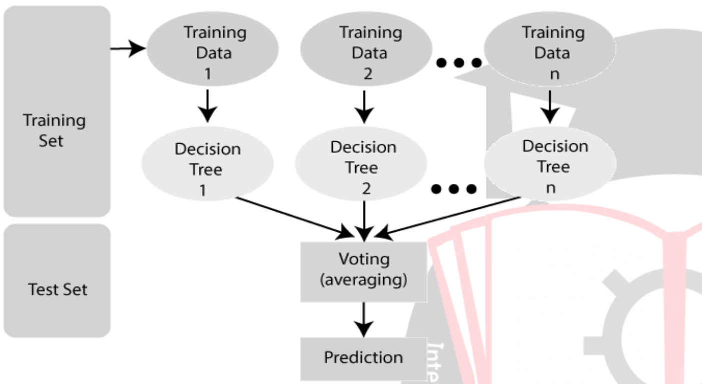

Fig.5. Random Forest Algorithm

E. Artificial Neural Networks

Inspired by the properties of biological neural networks, Artificial Neural Networks are statistical learning algorithms and are used for a variety of tasks, from relatively simple classification tasks to computer vision and speech recognition.
ANNs are implemented as a system of interconnected processing elements, called nodes, which are functionally analogous to biological neurons[13].The connections between different nodes have numerical values, called weights, and by altering these values in a systematic way, the network is eventually able to approximate the desired function.

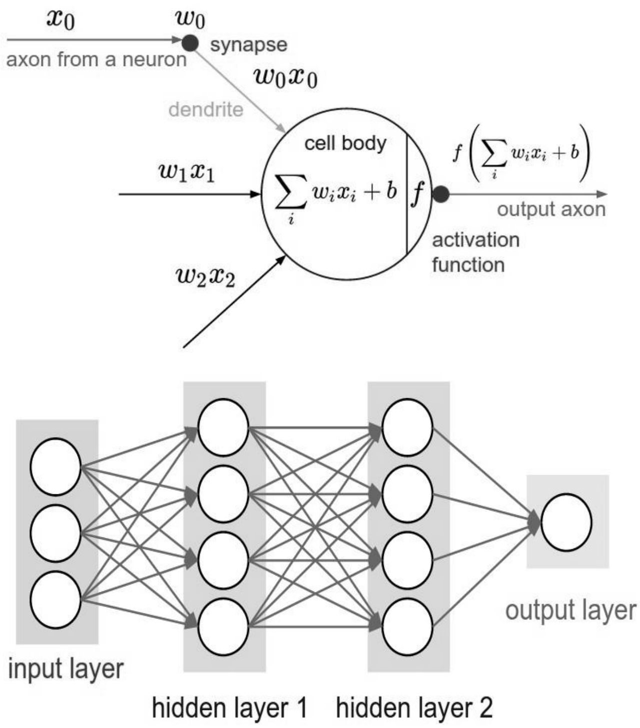

Fig.6. Artificial Neural Networks

The hidden layers can be thought of as individual feature detectors, recognizing more and more complex patterns in the data as it is propagated throughout the network. For example, if the network is given a task to recognize a face, the first hidden layer might act as a line detector, the second hidden takes these lines as input and puts them together to form a nose, the third hidden layer takes the nose and matches it with an eye and so on, until finally the whole face is constructed. This hierarchy enables the network to eventually recognize very complex objects.

F. Convolutional Neural Networks

Convolutional neural networks (CNN) is a special architecture of artificial neural networks. CNNs uses some of its features of visual cortex and have therefore achieved state of the art results in computer vision tasks. Convolutional neural networks are comprised of two very simple elements, namely convolutional layers and pooling layers. Although simple, there are near-infinite ways to arrange these layers for a given computer vision problem. The elements of a convolutional neural network, such as convolutional and pooling layers, are relatively straight forward to understand.

The challenging part of using convolutional neural networks in practice is how to design model architectures that best use these simple elements[18].

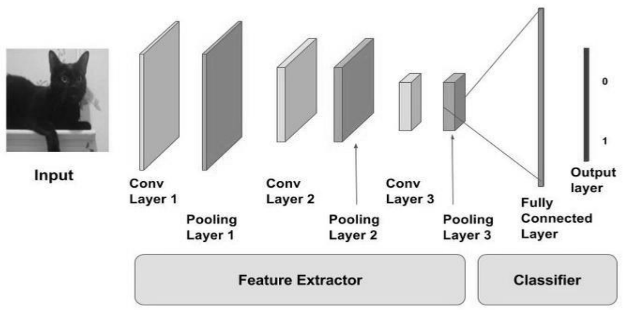

Fig.7. Convolutional Neural Network

Convolution is one of the fundamental building blocks of CNNs. The prime objective of the convolutional operation is to extract features like edges, curves, corners, gradient orientation, etc from the input image.

Table 1: Performance evaluation

Classifier	Accuracy	Precision	Recall	ROC
SVM	85.68%	0.86	0.87	0.86
Decision Trees	84.61%	0.85	0.84	0.82
KNN	86.32%	0.86	0.86	0.88
ANN	83.10%	0.88	0.87	0.88
CNN	91.11%	0.93	0.89	0.97

IV. CONCLUSION

In this review paper, different image classification techniques are studied. Based on study of the performance evaluation (accuracy) of different algorithm, it is observed that Convolutional Neural networks (CNN) gives the best results in computer vision tasks for image classification.

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