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Overview of Deep Learning: Applications in Various Areas

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Abstract
Deep learning is an emerging field in the sense of artificial intelligence. Deep-learning innovation powers numerous parts of current society: from web quests to content sifting on interpersonal organizations to proposals on web-based business sites, and it is progressively present in shopper items, for example, cameras and cell phones. Deep learning offers effective procedures to discover designs in information for taking care of testing prescient issues. Deep learning is widely used now in various applications like speech recognition, pattern recognition and image processing. This paper discusses the overview of Deep learning, its various applications and various techniques used in deep learning.

Keywords: *Deep learning, Convolutional neural networks, Recurrent neural networks*

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INTRODUCTION

Traditional machine-learning systems were restricted in their capacity to process common information in their crude shape [1]. There are various artificial intelligence projects developed to convert real knowledge into various languages. Using inference rules, the machine can make decisions based on logic used in these languages. Be that as it may, none of these undertakings prompt significant achievement. The difficulties confronted by frameworks depending on hard-coded information recommend that AI frameworks require the capacity to procure their own insight, by extricating designs from crude information. This ability is known as machine learning. Deep learning is an arrangement of strategies that permits a machine to be bolstered with crude information and to consequently find the portrayals required for identification or grouping.

The main aim of machine learning is to represent input data and generalization of learnt patterns for solving challenging predictive problems. For example, deep learning uses artificial neural networks to solve problems by learning feature representations from large amounts of data. It totally depends upon [2] how data is represented and learnt because a good data representation can result in high performance for relatively simpler machine learner. In deep learning, difficult patterns are recognized. For recognizing complex details, firstly very simple details are calculated; then based on these simple details more complex details are deduced, when the system goes deeper. Multilayer perceptron is an example of deep learning feed forward network, which has numerical capability to convert a set of inputs to desired outputs.

Figure 1 shows how deep learning recognizes an image. Firstly, we have a visible layer that contains actual input that is going to recognize [3]. In the second stage, there is hidden layer that detects details about edges which become input to third stage. Thus, in the deep learning model, there are sets of stages which are hidden layers. These are called “hidden” because instead of giving values, it determines the relationships in the observed data. First hidden layer depicts edges, second hidden layer depicts corners and contours, third hidden layer depicts object parts and the fourth gives output. Hidden layer is of two types: one based on weights and second based on activation function. Those representations comprise easy and also non-linear modules result in amelioration from one level into an illustration at a better, barely greater abstract degree. Deep neural networks can be divided extensively in three categories:

1. *Deep Learning Networks for Unsupervised Learning*: These are developed to take high order correlation data with the help of statistical distributions of associated classes.
2. *Deep Learning Networks for Supervised Learning*: These are trained with the labelled data, hence with each input output is associated.
3. *Hybrid Networks* involve classification of data using outputs of generation.

The reason why deep learning is so popular today is the drastic increase in chip processing abilities (e.g., GPU units), cheaper computing hardware, and recent advances in machine learning algorithms. Many companies and research institutes [4] involved in the deep learning research include Google, Facebook, Amazon, MIT, University of Washington, IBM, Apple, Microsoft Research, OpenAI, Baidu, Intel, Nvidia and many more. In the next sections, we discuss about need for deep architectures, various deep learning networks and their applications.

DEEP ARCHITECTURES

With the help of deep architectures like deep belief networks, RNNs we can use them in the field of image processing, speech recognition, natural language processing, audio recognition, machine translation, bioinformatics where they produce high accuracy as equivalent to human beings.

Perceptron

The perceptron [6] algorithm was invented in 1957 at the Cornell Aeronautical Laboratory. It contained only one feature layer at that time. The objects are recognized by adjusting weights with the help of all features. Thus, perceptron only contains input layer, output layer and hidden layer that computes features in the center.

Neural Network

Artificial neural networks (ANNs) in the field of computer science consist of large number of neurons. Every individual neuron registers utilizing summation work. The main goal is to beat the most extreme before multiplying to various neurons. These structures are self-learning and arranged, instead of modified, and surpass. The course of action or highlight distinguishing proof is difficult to express in a standard PC program. Figure 2 shows the neural network.

Fig. 1: *Deep Learning Model.*

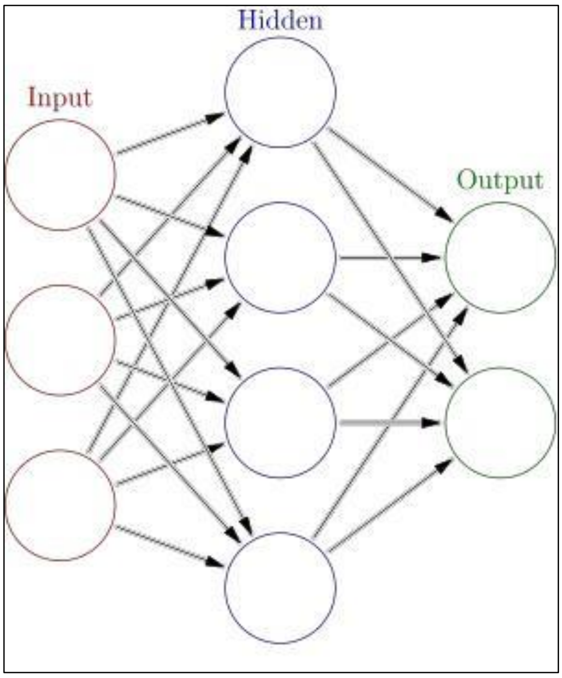

Fig. 2*: Neural Networks.*

Support Vector Machines

In machine learning, support vector machines are directed learning models with calculations that look at data used for course of action and backslide. In SVM, we plot every information as a point in n-dimensional space (where n is the number of elements you have) with the estimation of each component being the estimation of a specific facilitate. At that point, we perform order by finding the hyper-plane that separates the two classes exceptionally well. This is shown in Figure 3.

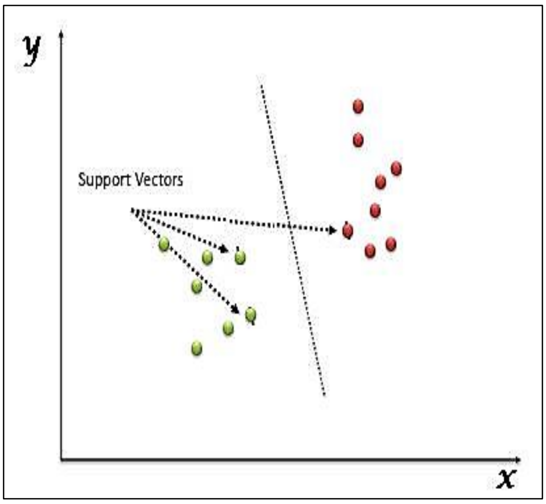

***Fig. 3**: Support Vector Machine.*

VARIOUS DEEP NETWORKS

Convolutional Neural Networks

ConvNets are planned to process [7, 9] data that comes as different bunches, for example, a shading picture made out of three 2D groups containing pixel controls in three shading channels. In convolutional neural networks, we have one-dimensional [13] for signs and groups; two-dimensional for images or sound; also, three-dimensional for videos (Figure 4). There are four properties of convolutional networks that include nearby bonding, shared weights, pooling, and the utilization of many layers.

Recurrent Neural Networks

Unlike feed-forward networks, the outputs of recurrent neural networks (RNNs) can depend on past inputs, providing a natural framework for learning from time series [7] and sequential data. But training them for tasks that require long-term memory is especially difficult due to the vanishing and exploding gradients problem [8], i.e., the error signals for adapting network weights become increasingly difficult to propagate through the network. RNNs are very powerful dynamic systems but training them has proved to be problematic because the back-propagated gradients either grow or shrink at each time step.

In Figure 5, input is x which is word, hidden states which is function of previous hidden state and new input and o is output. U, V, and W are parameters that are shared across time.

Deep Learning Applications

Deep learning is now used in various fields. Deep learning has numerous applications ranging from image processing, signal processing, natural language processing, medical, and many others. In this section, we will discuss various applications of deep learning in various fields.

Classification, Detection of Objects in Images, and Generation of Captions

This task requires the classification of objects within the image. Deep learning is very good, much better than human beings, in recognizing objects given previously trained on large data set of images.

Figure 6 shows how deep neural network detects different objects in an image. The extension of this application is the generation of captions from image. The input here is image and output is actually a text describing what is happening in that image

Like in Figure 7 showing text is generated from image *"man in black shirt is playing guitar"*. The use of this application is captioning applied for blinds. Facebook is going to apply the same technology for the blind people using camera in front of images. Literature shows that this problem shows very good results with convolutional neural networks.

Deep Sound

Here the data is different which deals with sound. Deep learning-based algorithms take sound as input and are able to recognize words and, therefore, convert speech to text. Google now and Siri are some applications developed by Google and Apple which extensively use deep learning.
Figure 8 shows sound waves of hello are converted to hello text by applying deep learning algorithms. DBNs (deep belief networks) are probabilistic generative models that are composed of multiple layers of

stochastic, latent variables [10]. These are built from restricted boltzman machines (RBN), which are used in speech recognition.

Translation of Text from One Language to Another

Machine interpretation has been around for many years that involves translation from one language to another. There are various methods that involve statistical translation methods, mapping methods. In this we have pair of languages, e.g., in Figure 9, we have English to German translation using deep neural network which gives better results than previous technologies.

There are various machine learning tool kits for machine translation that involve tensor flow and tensor flow unit, which uses deep learning. Google has recently developed a new processor unit which is called tensor processing unit that is built specifically for machine learning. TPU provides low-precision arithmetic and it is kind of programmable Artificial intelligence accelerator and it does not involve training but involves running models. The interesting application of this is Smart Reply feature from Google inbox (Figure 10).

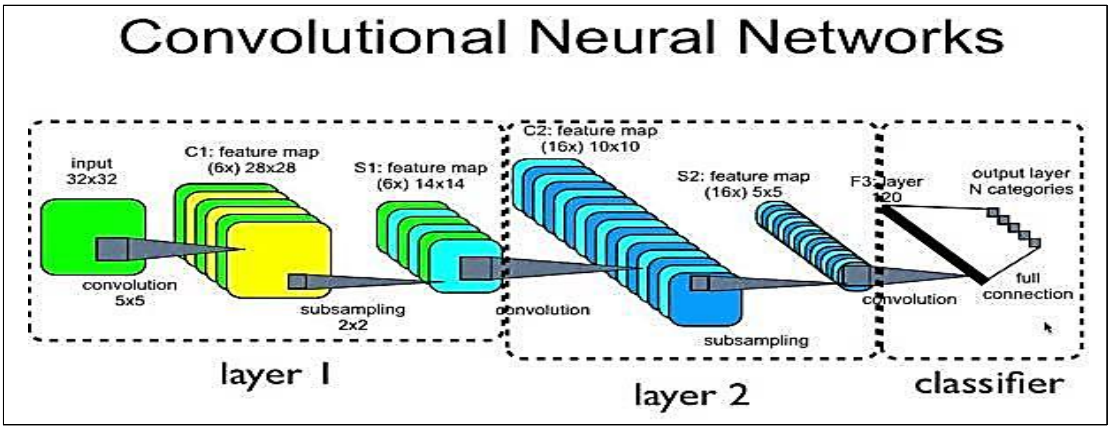

Fig. 4: *Convolutional Neural Networks.*

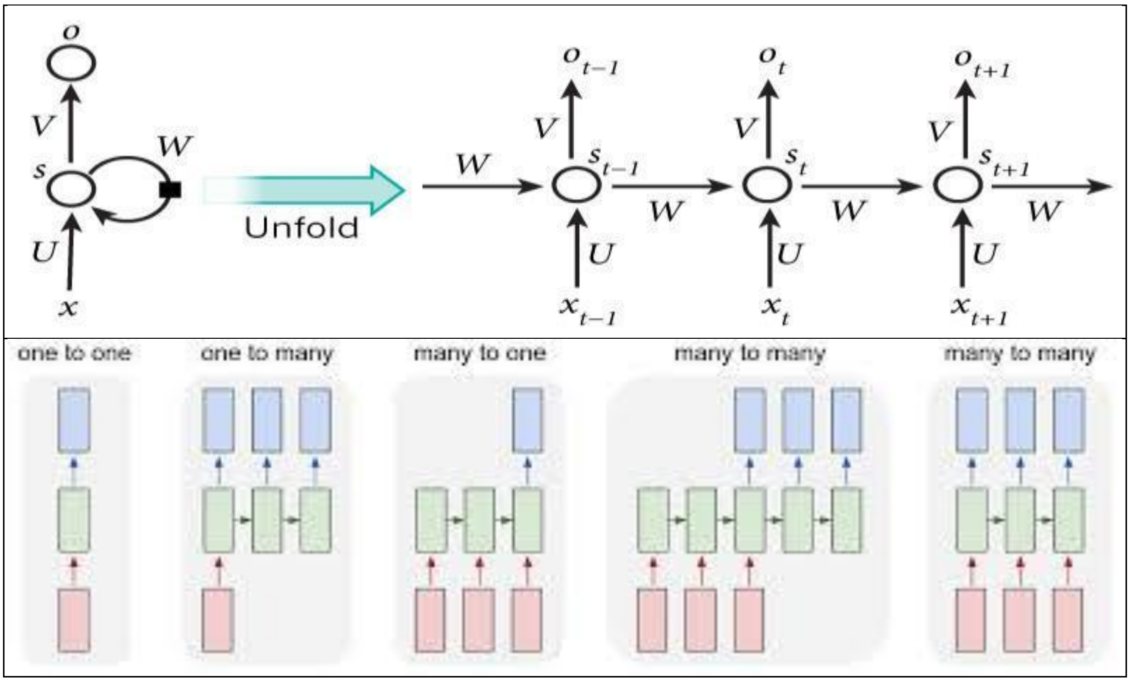

Fig. 5: *Recurrent Neural Network.*

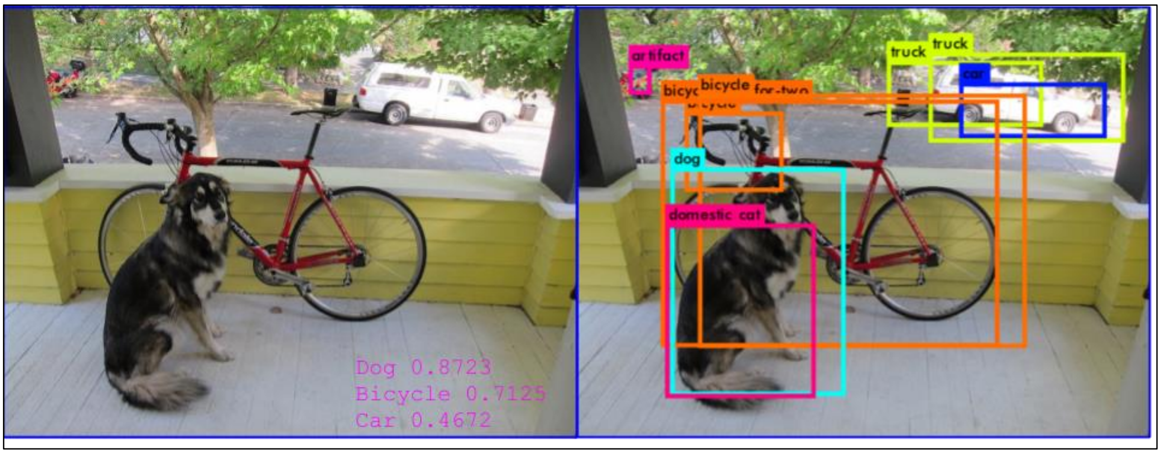

Fig. 6: *Object Detection Using Deep Neural Nets.*

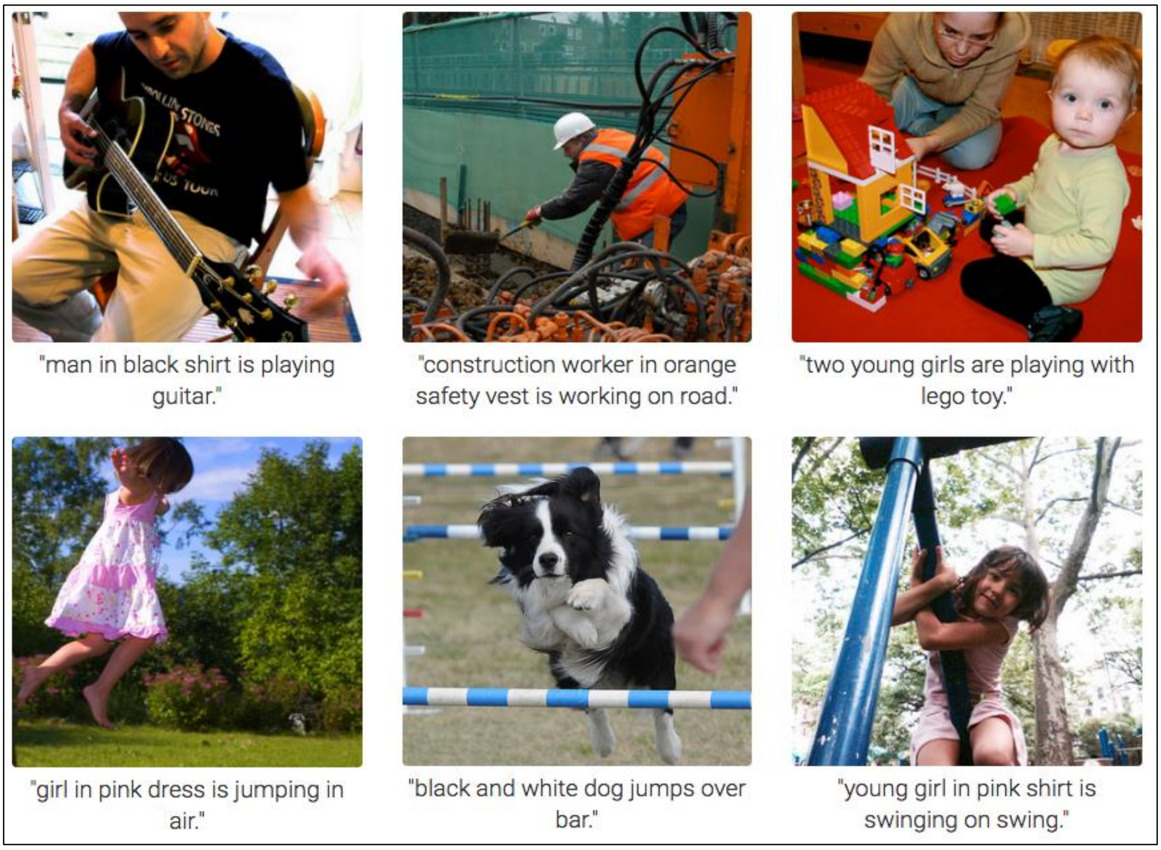

Fig. 7: *Caption Generation from Images.*

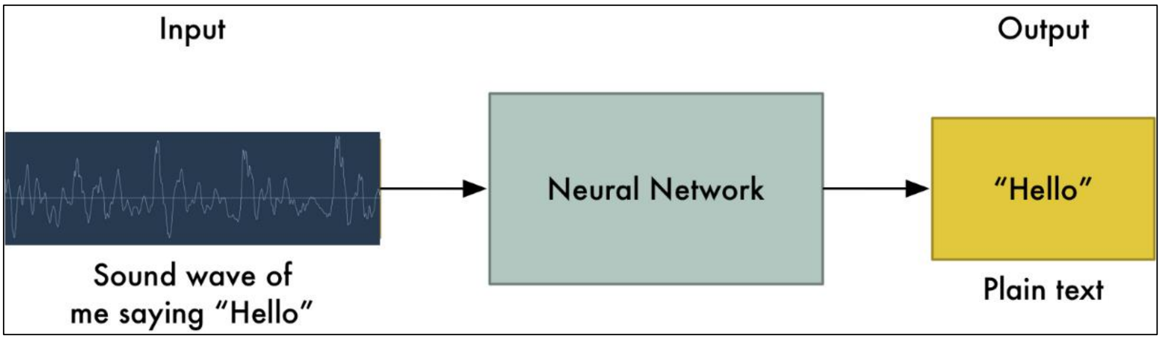

Fig. 8: *Speech Recognition Using Deep Learning.*

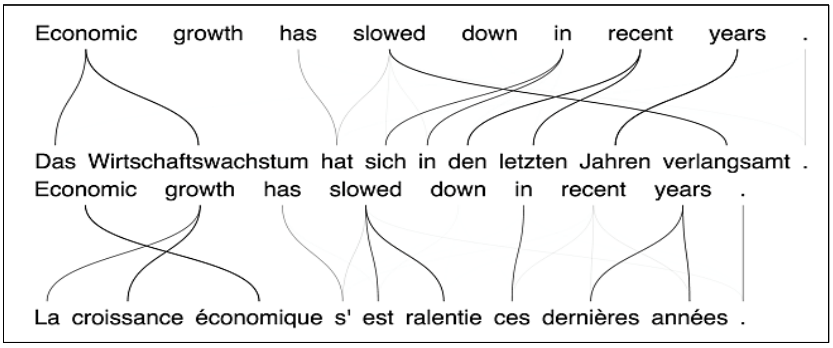

***Fig. 9**: Translation Using Deep Learning.*

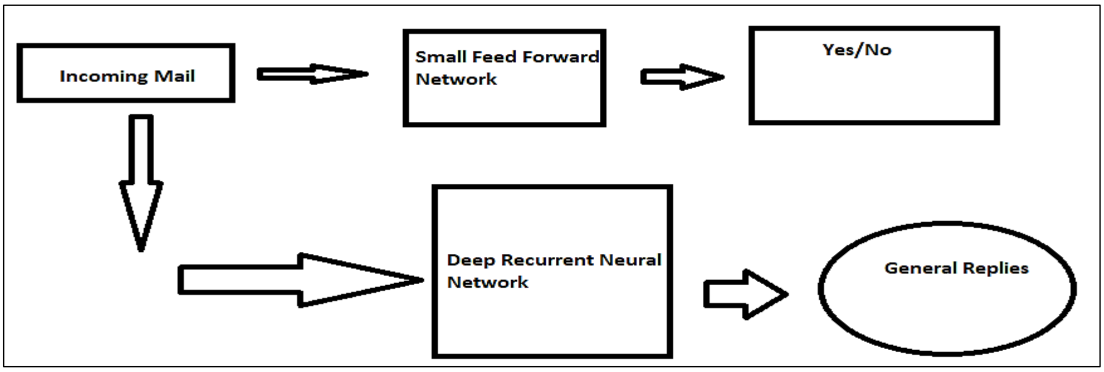

***Fig. 10:** Smart Reply of Google Using Deep Learning.*

It uses two neural nets, one small neural network to decide whether or not they can provide a smart reply and if it provides, it will engage bigger neural network to actually generate smart reply.

Medical Applications

Deep learning has been increasingly popular in computer vision, text understanding, and speech recognition. There are technical advances in the field of medical surgery [11]. Deep learning [12] is very useful in detecting images in brain tumor, medical image analysis, X-ray images, tissue-regulated splicing code, segmentation of microarrays, drug-induced liver injury, and protein contact map predictions. Deep neural networks are very useful to automate the diagnosis of retinal disease. Retinal disease is a terrible illness and the ability to automatically assess retinal disease is a breakthrough.

In Figure 11, the image of retina is fed into a pre-trained deep convolutional network and output is detection of retinal disease if it exists. Another medical application is diagnosing skin cancer using neural networks—a network is trained to recognize whether a mole on the skin is dangerous or not. Figure 12 shows detection of skin cancer on skin.

Colorization of Images

There is a problem of converting black-and-white images to color images, traditionally [4] done manually with great effort because it is a very tedious task. Deep learning can be used to use the objects and their context within the photograph to color the image. It requires labelling of colors on the grayscale target image.

Some techniques involve scribble-based colorization (by providing colorful scribbles on target images), and example-based colorization (learn from reference images). Figure 13 shows colorization of grayscale images.

Agriculture

In agriculture, there are a large number of companies applying deep learning to several aspects from monitoring crops to controlling equipment in the fields to predicting and optimizing yields. Deep learning can be used to improve the productivity of crops by identifying [14] crop diseases and reduction of pesticide usage.

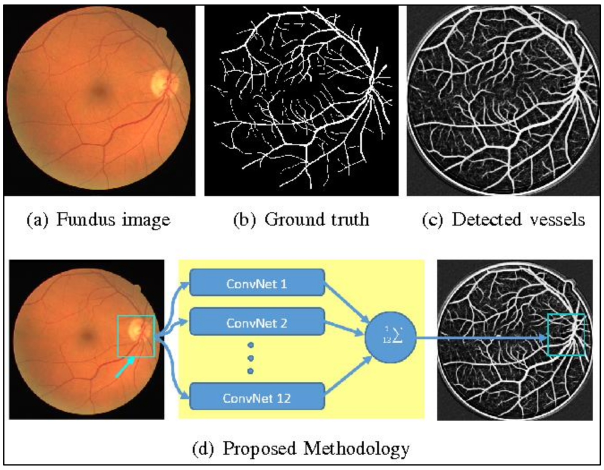

Fig. 11: *Retinal Disease Detection Using Deep Learning.*

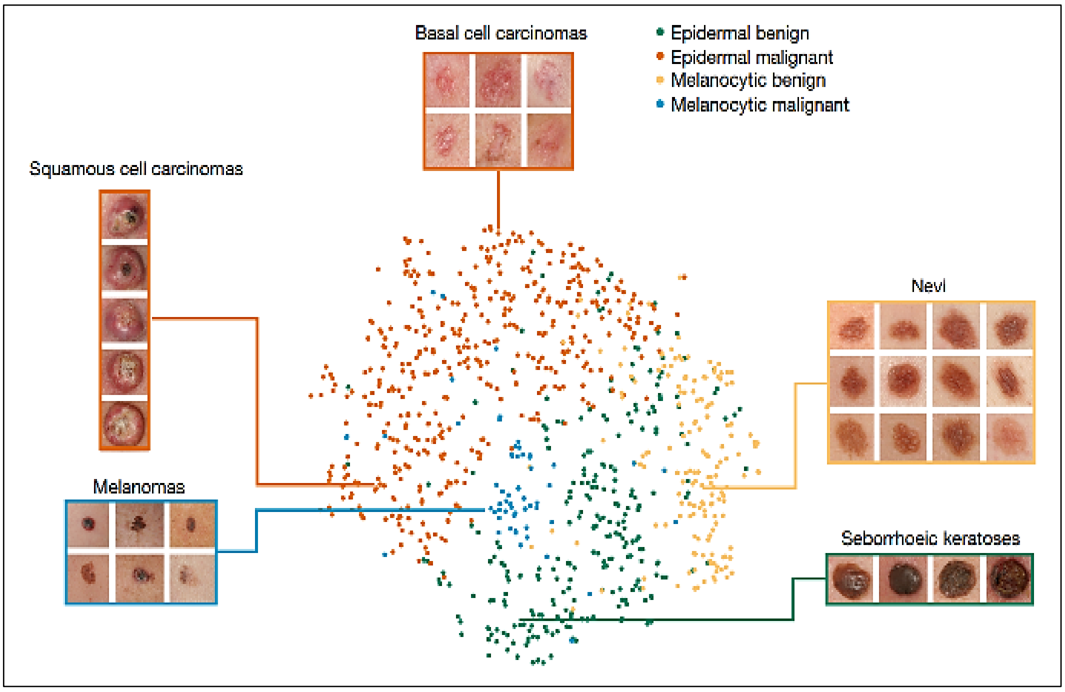

Fig. 12: *Skin Cancer Detection Using Deep Learning.*

Fig. 13: *Colorization of Images Using Deep Learning.*

Deep Learning Applications in Data Mining and Big Data Analytics

The main aim of deep learning is automation of extraction of representation from the data. The algorithms use huge amount of unsupervised data to automatically extract complex representations [2]. The deep architectures used in extraction of useful information are support vector machines and decision trees. The representations here are abstract because more abstract representations are constructed from less ones. "Big-Data" means a huge amount of assorted data that is organized and unstructured, which is very difficult to process based on traditional databases. The Big Data can be described by characteristics, namely, volume, variety, velocity, variability, veracity, and complexity. Since because of large volume it is very difficult to process this data, deep learning can be applied to this complex and unsupervised data for extracting useful information. It involves semantic indexing, discriminative tasks, and data tagging. Semantic indexing involves the representation of data in a more efficient manner. Discriminative analysis in Big Data analytics can be the primary purpose of the data e.g. semantic tagging for searching. Deep learning performs this tagging by applying linear models on complicated features, extracted by deep learning algorithms

Deep Learning for Detecting Robotic Grasp
Robotic grasping is a challenging problem involving perception, planning, and control. Many deep learning algorithms are very useful in robotics grasping. Lenz et al. [15] presented a two-step cascaded structure with two deep networks, where the top detections from the first are re-evaluated by the second. The first network has fewer features, is faster to run, and can effectively prune out unlikely candidate grasps. The second, with more features, is slower but has to run only on the top few detections.

Handwritten Recognition System
This is an undertaking where given a corpus of penmanship illustrations, produce new penmanship [16] for a given word or expression. The penmanship is given as a succession of directions utilized by a pen when the penmanship tests were made. The connection between the pen development and the letters is found out and new illustrations can be produced impromptu. Gradient-based learning techniques using multi-module machine learning models are a precursor to some of the initial end-to-end modern deep learning models for handwritten text recognition. CNN [18] models are used for classification of words and long short-term memory (LSTM) for character recognition. Figure 14 shows the whole process.

Automotive
As in self-driving cars, deep learning will perhaps coordinate into computerized driving frameworks to recognize and decipher sights and sounds that may be past the limit of people. In self-driving cars, deep reinforcement learning is used for motion planning, convolutional neural networks for end-to-end learning of the driving task, and recurrent neural networks for steering through time.

Military
Automatons are especially appropriate to profound learning. Consequently, interest in deep machine learning has not been limited to academic research [17]. Recently, the Defense Advanced Research Projects Agency (DARPA) has announced a research program exclusively focused on deep learning.

Surveillance
Here too, automatons will assume a part, yet the possibility [18] of PCs that can detect and translate with a human-like level of precision will change the path in which reconnaissance is finished.

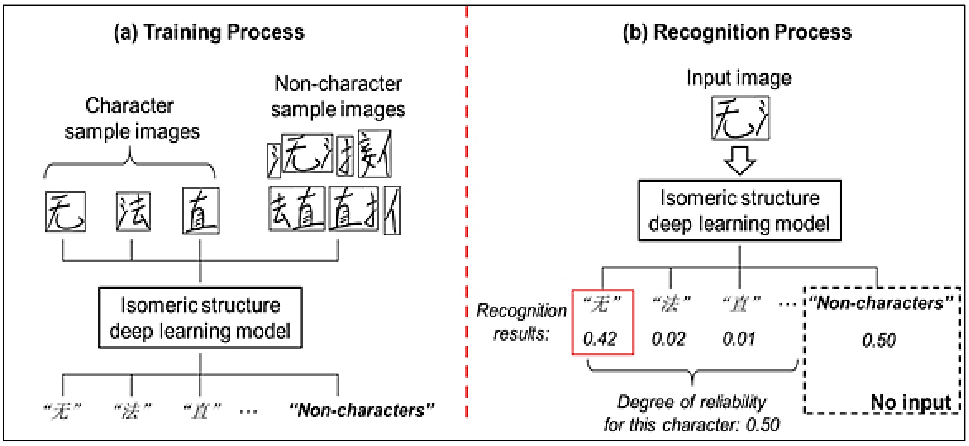

***Fig. 14:** Handwritten Text Recognition Using Deep Learning.*

CONCLUSIONS

Human vision [19] is a dynamic procedure that successively tests the optic cluster in a smart, assignment-particular way, utilizing a little, high-determination fovea with a vast, low-determination encompass [20]. We expect a significant part of the future advances in vision to originate from frameworks that are prepared end-to-end and join ConvNets with RNNs that utilization fortification figuring out how to choose where to look. Frameworks joining profound learning and fortification learning are in their initial stage, however they as of now beat detached vision systems at grouping errands and create great outcomes in figuring out how to play a wide range of computer games. Significant advances in computerized reasoning will happen through frameworks that consolidate portrayal learning with complex thinking. Albeit profound learning and straightforward thinking have been utilized for discourse and penmanship acknowledgment for quite a while, new ideal models are expected to supplant administer-based control of typical expressions by operations on substantial vectors.

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