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A Review of Area and Applications of Deep Learning Techniques

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ABSTRACT

The objective of the comprehensive field of computer science recognized as artificial intelligence (AI) is to build intellectual technologies which can accomplish jobs that usually call for human brainpower. Although artificial intelligence is a multifaceted, interdisciplinary discipline, expansions in machine learning (ML)and deep learning (Dl) in particular are revolutionizing virtually all range of industry's technical development and integrating AI into corporate settings. AI increases employee productivity, improves the overall customer experience, and lessens the extent of time disbursed on repetitive tasks. The objective of this study to review various methodologies and algorithms in DL, area and applications of DL techniques and advantages and disadvantages of DL techniques.

Keywords: Artificial Intelligence, Machine Learning, Deep Learning, Artificial Neural Network, Convolutional Neural Networks

1. Introduction

Over the last ten years, artificial intelligence (AI) has rapidly grown and extended throughout both business and academia. Processing raw data as an input in its original format was beyond the capabilities of traditional machine learning (ML) methods [1].

AI is a subclass of machine learning (ML), with deep learning (DL) as a subtype. Figure 1 illustrates the vast multilayer network that makes up DL. Artificial neurons that mine the pertinent characteristics without human assistance make up each layer. These attributes are employed to characterize unlabelled or labelled raw data in a variability of requests, comprising speech recognition and image classification. Because of its inherent feature extraction capability, DL has surpassed competing machine learning and AI technologies for human success in a number of fields [2].

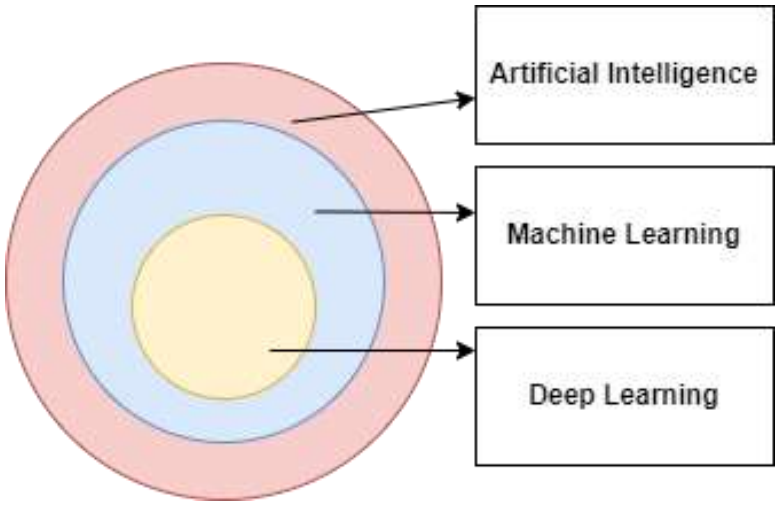

Figure 1: Development of AI, ML, DL

The learning technique used in DL is to be done either by supervised or unsupervised mode. Figure 2 provides a diagrammatic explanation of the operation. First, input is collected, and then several layers are added. An input is received, processed, and output is produced by the first layer. The production of the previous layer is grabbed by the buried layer or subsequent perceptron and read as input. Until the number of layers was not covered, the same procedure was used. Finally, the intended result will be generated.

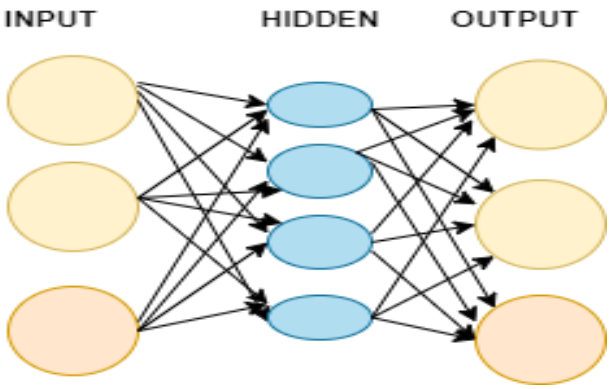

Figure 2: Deep Learning Structure

2. Methodologies in Deep Learning

Similar to machine learning techniques, DL is divided into three categories: supervised, unsupervised, and partial-supervised (see to figure 3). Aside from these three categories, there is a fourth one called as Deep Reinforcement Learning (DRL) [3].

- **Supervised learning**

This method uses labelled data as the input to the network. Several inputs (training set input data) and outputs (training set output data) make up the network architecture in this method. In the phrase

$$y = mx + c \qquad (2.1)$$

where, y is the dependent variable i.e. determined by the input variable x, and c is a biassed value that is constant across all inputs. The smart agent predicts the outcome and contrasts it with the real outcome, y. In order to reduce the cost error function, the agent first calculates it and then adjusts the network learnable parameters.

Following training, the agent is capable of accurately generating the right output based on the input. Convolutional Neural Networks (CNNs) (CNN), Deep Neural Networks (DNN), Recurrent Neural Networks (RNN) coupled with Gated Recurrent Units (GRU and Long Short Term Memory (LSTM), and) are the many methodologies under supervised deep learning models.

- **Unsupervised Learning**

Similar to supervised learning, this method does not utilise tagged data. The technique uses only independent variables as predictors. The computer has no data to use as a baseline for predicting new data since this method does not employ dependent variables. This algorithm is capable of grasping more complex processing than the supervised machine learning method.

- **Semi-supervised or Partial Learning**

Both supervised and unsupervised learning methods are included in this learning system. During the learning process, it takes in both labelled and unlabelled data.

- **Deep Reinforcement Learning (DRL)**

In 2013, DRL started collaborating with Google Deep Mind [3]. Deep Mind aimed to develop an artificial agent capable of performing and generalizing at a level comparable to that of humans. Like humans, agents can learn on their own to implement appropriate policies or activities that will benefit them in the long run. One approach of learning that uses trial and error through hits and misses is called reinforcement learning. Instead of employing hand-crafted feature extraction, the agents, like humans, use raw data (as input) to increase their expertise. As a result, DRL combines deep learning with reinforcement learning.

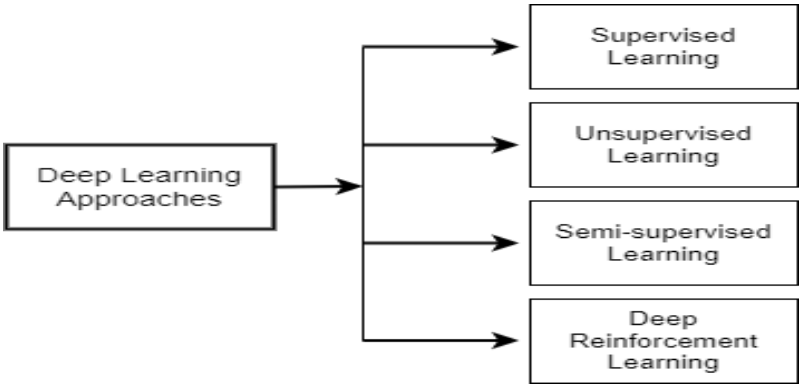

Figure 3: Deep Learning Approach's Classification

3. Algorithms in DL

DL architecture can be basically demarcated as an Artificial Neural Network (ANN) with more than two or two hidden layers pointing at increasing the forecast accurateness. DL is such a standard approach that supports the structure for understanding the difficult perception tasks with the extreme accuracy. As, it is totally based on the layers, each subsequent layer receives the output of past layer as an input.

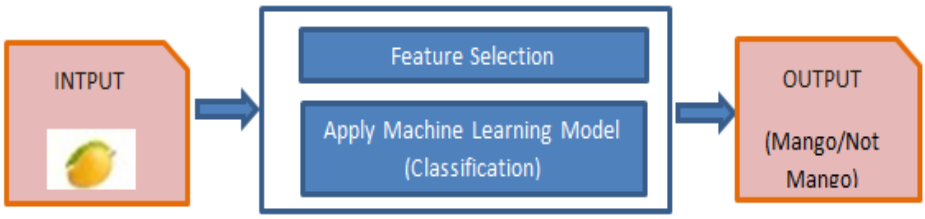

Figure 4: Work Flow of Deep Learning

- **Convolutional Neural Networks (CNN):** One of the most advanced DL algorithms; it processes data by mining features and putting it through many layers to show convolutional operations. It is made up of different layers [4].

The Convolutional Layer: is prepared up of Rectified Linear Units (ReLu), which precise the feature map over time. An activation function, a mathematical formula that controls a neural network's output, is applied using ReLu. Each neurone has an element-wise function linked to it.

The Pooling Layer: castoff to precise these feature maps in the subsequent stream. Pooling is a down-sampled sampling procedure that shrinks the feature map's dimensions. The concluding product is a 2-D array made up of linear, extended, uninterrupted, and single paths that have been compressed into a map.

Fully Connected Layer: It recognises the picture by categorising it and creates the compressed matrix or 2-D array that was retrieved as input from the pooling layer. Changing information into a 1-D array for input into the following layer is known as flattening.

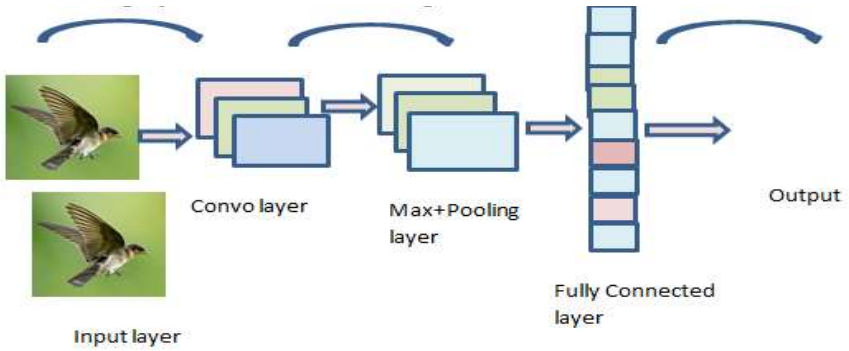

Figure 5: An Illustration: Convolutional Neural Network

- **Recurrent Neural Networks (RNN)**: In this area of artificial intelligence, a temporal sequence is used to help the network connecting nodes create a directed graph. RNNs are based on feed forward neural networks, which handle input sequences of varying length by using their internal state, or memory.
- **Deep Neural Networks (DNN):** The structural component of DL, a single neuron in a neural network, is called a perceptron. Multiply each input by a weight (theta (θ) 1 to theta (θ) m) given a finite collection of n inputs (for example, n in words or pixels). Subsequently, we apply a bias, sum up the weighted grouping of inputs, and lastly run them via a non-linear activation function [5].
- **Long-Short Term Memory (LSTM):** Long Short-Term Memory networks, or LSTMs for short, are a special kind of RNN that may develop long-term needs. It is widely effective for a variety of issues. Additionally, it reduces the vanishing gradient issue and is frequently used to time series data [6].
- **Restricted Boltzmann Machine (RBM):** It was Ackley who first proposed RBM. A particular type of Markov random field with dual layers—a stochastic observable level and a stochastic hidden layer—is widely referred to as RBM. A bipartite graph is used in practice to depict RBM. For multiclass classification issues, RBM's functionality is not worth it [1].

4. Area and Applications of DL Techniques

ML techniques have established to be highly beneficial in a variability of domains, such as computational learning, pattern recognition, and natural language processing. To report on trials in computer vision, voice and pattern recognition, face alignment, and detection, a variety of ANN techniques have been used in both academic and commercial settings [7]. It has been witnessed that deep learning practices are developing quickly and have had a significant impact on signalling and information processing [8].

- **Agriculture**

The remarkable achievements can be attributed to the advancement of DL in several areas. The larger area of agriculture includes temperature monitoring, crop production, soil management, and automatic plant disease detection.

- **Healthcare**

Advances in diagnostic tools and smart gadgets enhance the quality of health care systems, and smart health care practices are linked to advanced therapy. By providing accurate information about medical conditions, smart health care systems help individuals make the right decisions in emergency circumstances. Real-time access to diagnostic information, health alarms, inventories, and patient records, among other things. Connected smart health care systems will benefit both patients and healthcare practitioners [9].

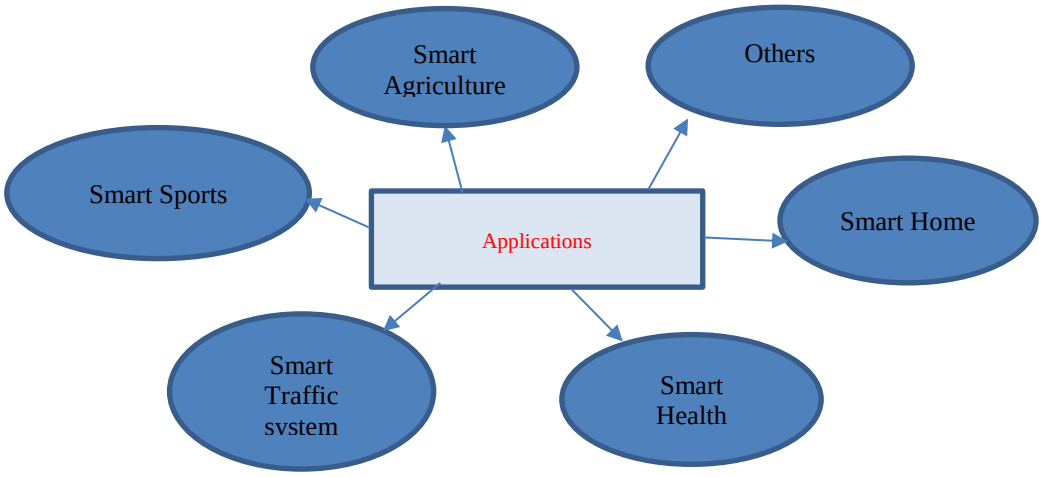

Figure 6: Expansion of DL in multifarious fields

- **Smart Home**

Digital technologies that enhance operations are created in smart homes through the integration of several sensors, data collection, and communication. The greatest concept for elderly and handicapped people is a smart house [10].

- **Smart Sports**

Broadcasting, regulating, monitoring, coaching, motion tracking, analysis, and physical education are all magical aspects of modern sports. Athletes are protected against injuries by risk monitoring and 3D trajectory tracking made possible by developing technology. Anyone, wherever, at any time, may read it from a smartphone screen, and it improves athletes' performance [11].

- **Smart Traffic System**

DL is often employed in traffic prediction, as the name implies. One of the greatest substitutes for displaying the optimal route and forecasting traffic conditions is Google Maps. For those who are unfamiliar with new locations and wish to learn more, it is the best app [12].

Based on the applications listed above, DL has had remarkable success in each of the fields. Since health is the main issue these days, professionals need assistance in order to address the reduction of sickness.

Table 1: Areas and Applications of DL Techniques

Area	Application	Input Data	Methods	Reference
Medical Informatics	Prediction of disease	Electronic health records (EHR),	Deep Auto encoders	[13]
	Inference of disease after monitoring Human behaviour	Big medical dataset	DBN	[14]
	Data Mining	Blood/Lab tests	RNN	[15]
Epidemiology	Predicting demographic information that ill-effects that human health	Social media data	Deep Auto encoders	[16]
	Air pollutant prediction	Spatio-temporal data	DBN	[17]
	Lifestyle diseases	Egocentric data	CNN	[18]
Clinical decision making/ Bioinformatics	Cancer Diagnosis	Gene Expression rather than tissue	Principal Component Analysis (PCA), Deep Auto encoders,	[19]
	Gene selection /Classification	Micro RNA	DBN, DNN	[20] [21]
	Drug design	Molecular compounds	DNN	[22]
Prophylactic/Medical Imaging	3D brain reconstruction,	3-D Images, MRI PET scans	Deep Auto encoders,	[23]
	Neural cells Classification		DBN	[24]
	Tissue Classification,	MRI, Fundus Images	CNN, DBN, Deep Auto encoders	[25]
	Tumour detection			[26]
Pervasive Sensing	Hand gesture recognition, Obstacle detection	Depth Camera, RGB-D camera Real-Sense camera	CNN,	[27]
			DBN	[28]
	Food intake	Wearable device, RGB Image, Mobile Device	Convolutional Neural Network, Deep Belief Network	[29]
	Energy Expenditure			[30]

5. Advantages and Disadvantages of Deep Learning

Table 2: Advantages of Deep Learning

Advantage	Description
Automatic feature learning	Deep learning algorithms don't need the features to be manually engineered since they can repeatedly learn them from the facts. This is particularly supportive for jobs like image recognition when the characteristics are tough to label.
Handling structured and unstructured data	Equally prearranged and formless data, including manuscript, audio, and pictures, may be controlled by deep learning systems.
Scalability	Cloud platforms and edge devices may be used to install deep learning models, which are readily scalable to house emergent capacities of data.
Generalization	Because deep learning models can learn intellectual and categorized demonstrations of the data, they may generalise efficiently to dissimilar situations or situations.
Predictive modeling	Administrations may utilise deep learning to estimate upcoming developments or occurrences, which helps in planned management and upcoming scheduling [31] [32].

Despite all of deep learning's benefits, there are a small number of disadvantages to take into explanation:

Table 3: Disadvantages of Deep Learning

Disadvantage	Description
High computational budget	Deep learning model training imposes substantial computing assets, such as robust GPUs and plenty of RAM. This might take a proportion of time and money.
Data confidentiality and security anxieties	Data safekeeping and confidentiality are concerns since deep learning algorithms frequently use a lot of data. Malevolent performers' mistreatment of data can have detrimental effects, comprising identity robbery, monetary damage, and confidentiality invasion.
Overfitting	When a model accomplishes poorly on fresh, anonymous data after being trained too fine on the training set, this is known as overfitting. This is a prevalent issue in deep learning, particularly with big neural systems, and can be brought on by a complicated model, a deficiency of regularization, or a lack of data.
Restricted to the data it’s trained on	Deep learning models can only create forecasts grounded on the data it has been trained on. They might not be capable to extrapolate to novel circumstances or settings that weren't included in the training set.
Absence of domain proficiency	A solid grasp of the field and the problem you are trying to resolve is necessary for deep learning. Expressing the problem and taking the right method might be puzzling if subject expertise is insufficient [33].

Conclusion and Future Scope Future Scope

Early detection and prevention of chronic illnesses are essential for patient care. From a collection of input data, deep learning techniques may extract hidden characteristics (knowledge). Models for predicting the risk of sickness based on medical data are therefore feasible. Many research undertaken by various organizations demonstrate that a single data modality (used for prediction) as well as a single predictive model are incapable of developing an intelligent system capable of anticipating the baseline and likely course of any disease in suspected humans. To solve the aforementioned issues, an intelligent system that might function as a hybrid model should be created.

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