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Analysis of Recent Advancement in Unsupervised Deep Learning

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> **Abstract**---Deep Learning (DL) has experienced considerable reach and success in the number of various application areas in recent years. The modern era of Machine learning has been rapidly developing and extended to most Convolutional fields of practice, as also to some new fields with more number of opportunities. Based on various categories of learning, numerous approaches have been suggested, including supervised, semi-supervised and unsupervised deep learning. The unsupervised deep learning aims to understand transferable image or video representations without manual annotations. Also, unsupervised approaches are needed when patterns that discern abnormal and normal behavior. In this paper, the recent development methods that are emerged in the domain of unsupervised deep learning are discussed. The various developments in the field of Auto Encoder are explained. The Deep learning structure like Convolutional Neural Network (CNN), Recurrent Neural Network (RNN) is considered as a recent method which is in development for improving the accuracy and to perform the classification in an efficient way.

Keywords---Deep Learning, Supervised based Learning, Semi Supervised based Learning, Unsupervised Deep Learning, Auto Encoder, Recurrent Neural Network (RNN). Convolution Neural Network (CNN).

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Introduction

Reliability, analysis of risk studies the stabile and problems of the device or system. For example, engineers of repair or product department used to measure the capability of the produced material or provision to work so that life can be correctly forecast. By exploring the historical pattern of inventories trading, decisions are taken by financial engineers to optimize results. [7]. In the view of the distant realms, reliability and risk analysis requires historical data analysis and forecast a quantified prediction. Decisions are taken which may be the likelihood of one device failure [7, 30], remaining useful life structure [7, 31], or techniques for trade [7,32]

Machine Learning method tries to resolve particular pieces of work that are not being told. In specific, of what to do in depth. Alternatively, Machine based Learning techniques make utilize of accessible information relating to the target nearby to the task to create statistical data patterns. In supervised Machine Learning techniques, pattern inference makes utilize of training information labeled where information points are clarify with the 'veritable' result. They allows templates to be inferred for the training dataset, the relation between input and output, which must then be tested on an independent examination and/or validated datasets of validation to avoid over fitting to the circulation of information set for instruction. Unmonitored Machine Learning procedures, by comparison are educated from samples of unlabelled data. Extensive examples are techniques for clustering based and anomaly based detection. [6]

Deep learning

In general, DL models encode one special extra before the method of data generation: the notion that connection of input data to input is production is reflected regarding tree like structure of several similar methods or blocks of construction. The soft presumption so far offers a substantially larger structure than prior to the uninvolved local constancy. Additionally, via topology of the prior, more assumptions about the previous can be encoded. [6]

The theory of studying relevant characteristics as the composition of similar features (potentially multilevel and hierarchical) turn off to be one among the most significant reasons for Deep Learning success. Many approaches for learning including advanced Feature Engineering (the recognition and construction of explanatory features of input have to be configured- deep networks also define helpful features manually) for each problem domain. Their hierarchical essence, in addition it enables the configuration of more up to date or clarified features from identical ones, including edges and contours of construction corners, which are marked by raw input data pixels.

These hierarchical features have been established once a deep network has the transition of the problem area is also possible for a certain problem domain. Representation of characteristics (multiple steps of network that are deep in nature to be a new issue with Machine Learning in the same area) [6]. The above one has enormous effect on functional implementation of deep neural networks, educating like scratch network not only put great request on the computing

support but it often usually needs very broad infrastructure datasets for instruction. Latest deep network quickly and easily contain ten millions of parameters that need to be set calculated. [6, 29]

The principle of deep based learning moves to light with records of smart expedient on methods that will support to identify malaria passenger in a picture regardless of where they are located [16] Over the years, DL based methods have been well researched in many areas, including anomaly detection. Many problems, however remain such as speeding up the identification and auto-polling of traffic patterns efficiently [17]

Deep learning are now becoming a current inclination in recent years, aimed at learning understandable patterns from highly-dimension and critical information. There are 3 major categories of algorithms for deep learning: supervised based, unsupervised based and semi-supervised based learning. The Supervised based learning attempts to construct methods from the dataset of labeled data. In comparison, the unsupervised generates methods from a dataset with no labeled data. [18]. Instead, in the method of testing and training the models, semi supervised method utilize limited number of labeled data and a huge number of no labeled data.

Deep learning algorithms like CNN [9, 33,34,35], Recurrent neural networks [36,37], autodidactic deep learning networks [9, 38] have become increasingly common in recent years and have been used for detection of intrusion and anomalies. Various deep learning methods are the methods used for supervised learning. Some of the studies shows that the deep learning methods perform better than conventional approaches, while interpretation and fine-tuning of the neural networks are sophisticated. [9]

The Deep neural networks mainly Conventional Neural Network consists of advanced growth in computer vision problem [1, 22, 23]. However, such developments were dramatically established upon supervised Deep learning method on large gathering of labeled image data's [1, 24, 25,26]. The supervised learning limit the usability and scalability for various practical implementation with restricted label budgeting. A basic solution is unsupervised learning with deep feature rendering which has latterly drawn dramatic attention [1, 27, 28].

Unsupervised learning (Fig 1) aims [12] to understand without manual annotations, transferable image or video representations. Clustering based representation learning techniques are among them, emerging as a promising direction in this field. Clustering-based strategies, unlike recovery based approaches, need little domain awareness while producing promising results [39]. Alone, the unsupervised training method seeks to distinguish regular and anomalous instance. In semi-supervised learning or supervised method of learning, unsupervised approaches may be pre-owned to more available mark normal or anomalous instance. Also, unsupervised approaches are needed when patterns that discern abnormal and normal behavior [15, 40]. Unattended DAD considered as a crucial area of study and of vital actual significance because of the limitations of other approaches [15, 41]



Fig 1 Block Diagram represents various schemes, methods and experiments [8]

Types of Deep learning ApproachesIt is possible to categorize deep learning methods as follows: supervised, unsupervised, and partially supervised or semisupervised learning. In addition, there is another learning method category called Reinforcement deep learning or Deep Reinforcement Learning ie D-RL which is explained below semi supervised method of or even under unsupervised method to learning. Fig 2 represent the pictorial category representation.



Fig 2 Deep learning Category [29]

Supervised Deep Learning

Supervised Deep learning is a method for learning which uses labeled information. The setting has set of inputs and corresponding outputs (at,bt) approximate ρ , in case of supervised DL method. For instance, if the intelligence agent predicts b^t=f(at) for input at, the agent receives a loss value of L(bt, b^t). The agent will change the parameters of the network iteratively to best approximate the desired outputs [29]. There are numerous deep-learning methods including DNN- Deep neural network, CNN, RNN includes LSTM-Long-Short-Term-Memory and GRU- Gated-Recurrent-Units.

Semi-supervised Deep Learning

Learning approach that takes place depending on partly labelled available datasets is semi supervised learning. DRL and GAN – Generative-Adversarial-Network are used as semi-supervised Deep learning methods in some circumstances. Further, RNN like LSTM, GRU are considered as well [29].

Unsupervised Deep Learning

Unsupervised Deep learning systems are those that can do so with no labels being present. In the above case, the agent discovers the interior identification/ essential characteristics within the input data to discover unknown relationships or structures. Clustering, reduction of dimensionality and reproductive methods are also taken as unsupervised deep approaches to learning [29]. There are many approaches in deep learning category, include Auto encoder, Restricted Boltzmann machines, non-linear dimensionality reduction. In addition, LSTM, RL often used for unsupervised learning.

Developments in Unsupervised Deep Learning Auto Encoder

Peng Jiang et.al., [7] explained in detail about the **auto encoder**s taken from the deep learning methods. Artificial based Neural Network (ANN) was used to replicate the actual input data by performing encode and decode process. Sparse auto encoder brings out the needed information specifically spatial information. Rectified Linear Units (RLU) and k-sparse are the kinds of sparse auto encoder. To acquire strong latent representation, stochastic noise to original data was introduced. For unsupervised Deep learning, Probabilistic method and Maximum Likelihood Estimation worked to produce efficient and consistent results. Deep architecture was designed to strive to construct a probability distribution method. Data's from the dataset may constitute spatial or temporal correlation, so for that they consider improved auto encoders which were the combination of CNN and RNN. The Deep structure designed was used to minimize the cost of computation. Alteration of the hyper parameters turns on the corresponding performance on the sample input data.

Priyadarshini Adyasha Pattanaik et.al., [16] proposed an extension of Computer Aided Diagnosis (CAD) method for the identification of the available of parasite in the blood. The parameters are trained initially by ANN followed by Sparse Stacked Auto Encoder. They consider 12500 to 2500-100-50-1 as the size of CAD, the input layer consists of 12500 number of nodes, the softmax output layer contain two nodes and 10- cross fold validation was used to make the classification reliable. SAE and SMC (Fig 3) are used to extract the features inorder to perform classification of the infected and non-infected malaria patients. TAE and SMC (Fig 4) called as Deep Staked Auto Encoder created to handle high input dimension. RBM and SMC (Fig 5) were combined for minor tuning of the deep neural network with less restoration of errors. The detection accuracy achieved was 89.10 percent, sensitivity was 93.9 percent and specificity attained was 83.1 percent respectively.



Fig 3 Double layer Sparse Auto Encoder + Softmax Structure [16]



Fig 4 Triple layer Sparse Auto Encoder + softmax structure [16]



Fig 5 RBM + softmax structure [16]

Xiang Li et.al., [21] developed a deep learning based unsupervised description swarm approach based on position state observance information for automated transient pattern recognition. As a criterion for transient extraction, sample entropy was used and prior testing and training step was introduced in auto encoder structure to learn effective consistency. To boost the clustering performance, a continuous representation clustering algorithm was further suggested. The dataset tests the usefulness and benefit of the developed approach, issue a developed instrument for transient selection in industrial scenario, in experiments on an actual world nuclear reactor condition. It gives a present outlook for deep based learning inspection of unlabeled data, and the point-to-point resultation scheme facilities applications in the nuclear industry.

Convolutional Neural Network

Bertil Schmidt et.al., [6] explained about the artificial neurons, functions and the methods involved in Deep unsupervised based learning. The Artificial neurons are the primary block of Artificial Neural Network (ANN) (Fig 6). There were three types of activation function considered. They are biologically inspired approximation of action potential, Rectified Linear Units (ReLU) (linear), softmax function (neither scalar nor consider the sum of weighted input of the variables). The most popular choice of the activation function was sigmoidal function for every neuron in the network. The networks like feed forward, Convolutional neural and Recurrent neural networks are the enhanced Deep learning techniques.



Fig 6 a) Artificial Neuron b) Multi Layer Perceptron c) Single layer of CNN d) Recurrent neural network e) Auto Encoders f) Generative adversarial network (GANS) [6]

Dongdong Xu et .al., [10] developed a Deep based approach concept depends on the Fusion process which was designed to minimize the computational cost and complexity. The supervised Deep Learning solution was used to consider the pretraining on other present labels which does not act well for testing process. The image fusion method was proposed based on the unsupervised CNN algorithm. The loss function called perceptual loss (Fig 7) was generated and mixed with design similarity loss. Two network was designed which contain one start point without side branches. The split up of the channel yield more flexibility. The change of the structure from the actual CNN to Dense Net produces multiple scale image transformation and makes it easy for regeneration.



Fig 7 Computation method of perceptual loss [10]

Long Tian et.al., [11] proposed a latest post processing and efficient loss function to evaluate the flow optical in an point to point unsupervised approach way. The CNN of non local term was developed to clarify the passage of data's by separating the noise and the blurred images present around the moving boundaries. To minimize the effect of occlusion, they planned to identify the occlusion step map from the bidirectional flows. The images from the dataset MPT sintel, KITTI and Flying Chairs were taken into account. Between the training processes they need inverse optical flow inorder to detect the occlusion. From the initial level to the bottom level the flow of optical, optical estimator, cost volume, warping were considered and up sampling of images were constructed for the taken images (Fig 8)



Fig 8 Extraction Process illustration [11]

Xihe Kuang et.al., [14] created unsupervised deep pipeline for vertebral segment of the input data's or images. They combine the sub optimal result of segmentated fabricated by rule based process with individual voting method inorder to provide supervision during training step. The proposed method provides high segmentation and establishes efficient vertebral process with improved accuracy. The main objectives are i) identifying ROI of every slice with rule dependent method ii) combine ROI through voting process to find the VOI iii) train CNN model to perform segmentation without depending upon VOI. To remove pixel variation in various tissues, local normalization was considered. Manual label was not considered rather positive and negative pixel was taken into account for supervision. Remove the laborious labeling in manual manner and resolve the issues of missing vertebrate and image distortion.

Ren-Hung Hwang et.al., [17] proposed an efficient anomaly detection mechanism for traffic flow named as D-Pack which was the combination of CNN and unsupervised Deep Learning i.e, Auto Encoder. The D-Pack was constructed to identify the first few bytes of some first packets in every flow for quick detection. The extracted characteristics are learned impulsive and traffic was straightly to the classifier. The non-linear description between the denoised input and anticipate output was identified to achieve the aim of end-to-end learning concept. The dataset considered for experimentation were KDD CUP 99, USTC-TFC 2016 and NSL-KDD. The IP address with malicious and benign flow does not influence the D-Pack classification process. Additional dense layers were added to CNN inorder to improve the performance. D-Pack structure minimizes the traffic volume during processing; absorb limited flow processing time and detection time and finally speed up the detection process in quick and easy manner. Using the proposed structure, they achieve 100 percent accuracy and 0.83 percent false positive rate.

Recurrent Neural Network

Yueyao Xu et.al., [18] proposed unsupervised method to perform information seganalysis. Autoencoder one of the developing unsupervised method was considered for data dimension and extraction of features. RNN algorithm taken into account to know the Long term temporary dependence from the input information. Chinese Poetry dataset was considered for analysis. Precision, F1 measures, Recall were the performance metrics taken for calculating the performance. The unsupervised proposed method successfully recognizes the text stegnography using unsupervised manner with no human intervention.

Unsupervised Deep Learning Approaches

Jiabo Huang et.al., [1] proposed a new Generic Unsupervised Deep Learning approach. This approach was used to direct deep models without the intervention of any manual governance. It discovered the focal point neighborhood to grasp about the below class decision bound. A single neighborhood was constructed so the remaining members share the paired labels inorder to perform the extraction of the needed features while performing training. Anchor Neighborhood Discovery (AND) which blend the advantages of Clustering and Sample Specificity. The architecture considered the absence of sample-to-sample correlation during learning of the model. AND method uses divide and conquer scheme for local sampling. It minimizes the erroneous of individual mined governance and utilize inter-sample relationship during unsupervised Deep Learning.

Da Xu et.al., [2] proposed a Deep enhanced Unsupervised learning to assign the misplaced information in the database of the patient. The architecture build up with an auto encoder substructure include the patterns that are missing, report for essential relationship in patient information, review the temporal patterns, loss function was used to error calculation and regularization. The new deep learning method minimizes the imputation bias and registered to various missing value thereby authorizes the physician and surgeons for better analyze of EHR for improved patient management. Deeper model minimize the amount of parameters and makes complex mathematical function easier. They consider 27,327 patient records for analysis. The proposed method produces accurate and reliable attribution

R.Janarthanan et.al., [3] felt that the real supervised based learning and unsupervised based learning process were breaking down to achieve minimal processing time and cut out with perfect during data execution to minimize the rebuilding rate of mistakes. So, they introduced an Unsupervised Deep Learning based Rebuilding Coder (UDRRC) (Fig 9) to achieve minimum computation time-11.25 ns during preprocessing and enhance the performance in feature extraction and selection process. Data analytics method was used to reduce the time of computation process. To perform the feature removal and identification in accurate manner, coder process combined with the Z-layer inorder to enhance accuracy and minimize the rebuilding error. The collected data's are tested on the available WISDM dataset which was open to public. The accuracy of classification achieved was 97.5 percent and Mean Square Error was 0.52 percent respectively.



Fig 9 Architectural Diagram of UDR-RC [3]

Yuxin Zhang et.al., [4] expressed a new deep learning unsupervised approach to detect the distraction of the driver while driving. The unsupervised multiple model Fusion based Network (UMMFN) contain three main split up i) multiple model representation learning (grasp the least dimensional heterogeneous sensor) ii) multiple scale needed information fusion (grasp both temporary dependent and spatio dependent from various modalities) iii) unsupervised detection of driver distraction (used CONVLSTM encoder-decoder method to perform classification using unsupervised task). UMMFN execute better than other existing models.

Xiangke Mao et.al., [5] explained that the unsupervised learning was the popular method because it didn't require manual interruption particularly in the rapid development of the information. Using the unsupervised learning, the significance of the sentence was calculated by the significance of the word they holds. To explain the correlation among the decision the pagerank algorithm was proposed. The documents were represented using graph and the nodes was represented as sentence in the material. Pre-process include the removing the stop words from the sentence, consider space of vector to identify the sentence. Markov Random method was considered to obtain score of all the nodes.

Md. Ahsanul Kabir et.al., [9] investigated and evaluated four different unsupervised deep based learning algorithm namely K-Means algorithm, Deep auto encoding Gaussian Mixture Model (DAGMM) (Fig 10), Self-Ogranizing Maps(SOM) and Adversarially based Learned Anomaly Detection (ALAD). For evaluation, they consider two various benchmark datasets namely full KDD and ISCX IDS dataset. DAGMM attain lowest false rate of about 0.9 percent and improved detection rate of 99 percent. The DAGMM contain two parts: Deep auto encoder network (reduction in dimension of the input data's) and Estimation network (forecast the substructure likelihood of Gaussian Mixture approach). SOM produce best results on remaining dataset. Computation amount of DAGMM is high than remaining algorithm i.e) K-Means and SOM. K-Means algorithm operated foremost on the attacks that are not known and obtains the identification rate of about 97.6 percent. The overview of the detection of anomaly is shown in Figure 11



Fig 11 Anomaly Detection process overview [9]

	K-Means	SOM	DAGMM	ALAD
	Algorithm			
Detection Rate	99.8	99.9	94	99.5
False Positive	3	9	1	27
Rate				

Table 2 Algorithms Performance on KDD dataset DR (Detection Rate), FPR (False
Positive Rate) [9]

	K-Means Algorithm	SOM	DAGMM	ALAD
Detection Rate	95	95.6	94	86
False Positive	9.7	7.9	36	54
Rate				

Table 3 Algorithms Performance on ISCX dataset DR (Detection Rate), FPR (False Positive Rate) [9] Xiaohang Zhan et.al., [12] developed a Online Deep Clustering-ODC inorder to get better of the unstableness learning of the visual representation. ODC was designed to carry out clustering and update of the network in simultaneous manner. The architecture designed with two modules i) sample memory- to reserve the sample labels ii) centroids and features memory –

used for evolution of centroids. ODC served as unite unsupervised tuning method that enhance the preceding self-supervised representation of various learning approaches. It does not require additional feature and extraction process. The techniques involved are loss reweigh assigning and allocated with small clusters to keep away from the stuck into trivial solutions. ODC are not cramped specially designed for rotation angle or prediction of colors.

Zilong He et.al., [19] proposed TopoMAD seq-to-seq model inorder to produce robust model which are spatial and temporal dependent among the present data's. The TopoMAD have two key features namely addition of topo information to identify the state of the system and unsupervised representation at point of training method and identification of threshold values. The proposed system included the system topo information to sort out the metrics. They select the spatial information with the aid of graph network and temporary character along with long term memory network. The unsupervised Auto Encoder was chosen to operate well with trained or contaminated data's. Two open source datasets were considered for analysis.

Haikun Qi et.al., [20] proposed a unsupervised deep learning method for quick detection of 3D non-rigid repository moving fields. The proposed 3D repository moving field was trained with auto encoder-decoder process. The Wrap function was taken to authorize the training without the base truth moving field. RespME-Net exhibit practical of knowledge non-rigid moving estimation using speckle of images along with speckle size. They consider 5 fold validation cross with the taken CMRA dataset.

Proposed Unsupervised architecture

Sarfaraz Husse in et.al.,[8] explained about the unsupervised based learning method to solve the restricted presence of the labeled information. Unsupervised technique used to resolve problems in several domain like speech processing, object classification, audio/video classification and categorization. The proposed method was divided into three steps: i) cluster on the characteristics taken from the input data i.e., images to judge the starting amount of labeled datas. ii) Calculate proportions of label communicate with each cluster. iii) The cluster assignments are used to know about the categorization of the tumors. The proposed approach produced about 24 percent to 9 percent development in accuracy. Fig 12 represent the proposed unsupervised approach.



12 Unsupervised architecture [8]

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Deep learning network reconstruction and extension of semi supervised

approachKaichao Liang et.al., [13] expressed about the dramatic development of Deep Learning in Low cost CT (LDCT). The pairing of the LDCT and normal CT dataset was expensive. To overcome the above problem, they proposed unsupervised Model dependent Deep Learning based method for Low cost CT restoration. The designed architecture was trained depending upon the maximum posterior loss function called G-Map with the low cost dataset alone. Primary idea was to realize the suitable loss method without the normal CT images. Fig 13 represent Deep learning based reconstruction network and extension of semi supervised learning approach. The architecture consists of projection block, domain transform for transformation. The projection block was used to remove the noise from the domain. U-Net structure was considered as the backbone because it considers the advantage of the local and global features. The domain transfer block image is divided into three parts i) Diagonal matrix weight W ii) matrix used for filtration M iii) weight projection matrix.



approach [13]

Conclusion

DL approach is a rapidly growing Machine Learning technology. The rapid use of Deep Learning Algorithms in various fields truly demonstrates its success and flexibility. Deep Learning achievements and improved accuracy rates clearly show the importance of this technology, clearly emphasizing the growth of deep learning and the trend for future development and research. Additionally, the notice points of unsupervised deep learning compared with other learning has the ability to unlock the previous solved problems and has also gathered large amount of attention in ML and in deep learning area too. The unsupervised Deep learning has a dramatic growth in medical field, nuclear prediction, weather forecast, driver status prediction etc. The cluster-based development used to improve the accuracy. In Auto Encoders changes are made to produce efficient result were discussed. The development in deep learning without human intervention will lead the predication in quick and efficient manner.

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Compliance with Ethical Standards

Conflict of interest Authors have declared that no conflict of interest exists.

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