**Current Trends of Machine Learning Techniques and its state-of-arts Applications**

**Dr. Swapnanil Gogoi**

**Gauhati University IDOL, Guwahati, Assam**

**Dr. Kshirod Sarmah**

**Department of Computer Science**

**PDUAM, Amjonga, Assam**

**Abstract**

Machine Learning (ML) addresses the question of how to build computer systems that develop their capabilities automatically through experience. It is one of today’s most rapidly growing technical domainat the core of artificial intelligence (AI) and data science, lying at the intersection of computer science and statistics. Recent progress in machine learning has been driven both by the development of new learning algorithms and theory and by the on-going explosion in the availability of online data and low-cost computation. Deep Learning (DL) has come into existence as the most innovative area for research in Machine Learning. It aims to act like a human brain, having the ability to learn and process from complex data and also tries solving intricate tasks as like human. The adoption of data-intensive machine-learning as well as deep learning methods can be found throughout science, technology and commerce, leading to more evidence-based decision-making across many walks of life, including health care, manufacturing, education, financial modelling, policing, and marketing. Human-computer interaction (HCI) is the study of human and computer activities and how they interact with each other. To facilitate this interaction, an interface is required between humans and computers. In this review paper we are going to discuss about some very important domains that machine learning has been applied that include Computer Vision, Automatic Speech and Speaker Recognition, Information Retrieval, Image Recognition, Expert systems ,Pattern recognition, Medical Diagnosis, Marketing, Natural Language Processing, Toxicology, Customer Relationship Management, Cyber Security, Bioinformatics and Online Advertising.

**1. Introduction to Machine Learning**

Machine Learning is a branch of [artificial intelligence](https://www.techsparks.co.in/artificial-intelligence-as-an-m-tech-thesis-topic-for-cse/) (AI) that gives systems the ability to learn automatically and improve themselves from the experience without being explicitly programmed or without the intervention of human. Its main aim is to make computers learn automatically from the experience and to create intelligent machines which can think and work like human beings. Here, we define learning as the recognizing and understanding the input data and taking informed decisions based on the supplied data. It is very difficult to consider all the decisions based on all possible inputs. To solve this problem, algorithms are developed that build knowledge from a specific data and past experience by applying the principles of statistical science, probability, logic, mathematical optimization, reinforcement learning, and control theory. A ML project involves first defining a problem then preparing data, evaluating algorithms, improving results and finally presenting results.

**2. Machine Learning Algorithms**

Machine Learning algorithms are categorized into the following three categories: (i) supervised, (ii) unsupervised, and (iii) reinforcement learning.

**2.1 Supervised Learning**

In supervised learning, algorithms are presented with a dataset containing a collection of features. Additionally, labels or target values are provided for each sample. This mapping of features to labels of target values facilitates encoding of knowledge.Once it has learned, the algorithm is expected to find the mapping from the features of unseen samples to their correct labels or target values. The training process continues until the model achieves a desired level of accuracy on the training data. Examples of Supervised Learning: Regression, KNN, Logistic Regression etc.

**2.2 Unsupervised Learning**

The purpose in unsupervised learning is to extract meaningful representations and explain key features of the data. No labels or target values are necessary in this case in order to learn from the data. Examples of Unsupervised Learning: Apriori algorithm, K-means.

**2.3 Reinforcement Learning**

In reinforcement learning algorithms, an AI agent interacts with a real or simulated environment. This interaction provides feedback between the learning system and the interaction experience which is useful to improve performance in the task being learned. Deep learning algorithms are a subset of Machine Learning algorithms that typically involve learning representations at different hierarchy levels to enable building complex concepts out of simpler ones. Example of Reinforcement Learning: Markov Decision Process.

**3. Benefits of Machine Learning**

Currently, every state-of-arts developments of computer science are dependent on machine learning techniques. Some benefits of machine learning techniques have been observed as follows:

**Decision making is faster –** Machine learning provides the best possible outcomes by prioritizing the routine decision-making processes.

**Adaptability –** Machine Learning provides the ability to adapt to new changing environment rapidly. The environment changes rapidly due to the fact that data is being constantly updated.

**Innovation –** Machine learning uses advanced algorithms that improve the overall decision-making capacity. This helps in developing innovative business services and models.

**Insight –** Machine learning helps in understanding unique data patterns and based on which specific actions can be taken.

**Business growth –** With machine learning overall business process and workflow will be faster and hence this would contribute to the overall business growth and acceleration.

**Improved Outcome –** With machine learning the quality of the outcome will be improved with lesser chances of error.

**4. Deep Learning Techniques**

Deep learning (DL) is one of the hottest fields in data science with many case studies that provide astonishing results in robotics, image recognition, speech processing and Artificial Intelligence (AI). Deep Learning has becoming a trend. Since deep learning attempts to make a better analysis and can learn massive amounts of unlabeled data, it has been applied to several of fields. There are various applications where deep learning is applied such as automatic speech recognition, image recognition, natural language processing, drug discovery and toxicology, customer relationship management, recommendation systems and bioinformatics.

Deep learning allows computational models that are composed of multiple processing layers to learn representations of data with multiple levels of abstraction. These methods have dramatically improved the state-of-the-art in speech recognition, visual object recognition, object detection and many other domains such as drug discovery and genomics. Deep learning discovers intricate structure in large data sets by using the Backpropagation algorithm to indicate how a machine should change its internal parameters that are used to compute the representation in each layer from the representation in the previous layer. Deep convolutional nets have brought about breakthroughs in processing images, video, speech and audio, whereas recurrent nets have shone light on sequential data such as text and speech.

Using the real context meaning of deep that is extending far down from the top or surface helps torepresent a non-linear function with fewer parameters. Due to the involvement of large complexity results, functions can be compacted using deeper architecture .As each parameter of the architecture might have to be learned or used; deeper architecture can be more beneficial to obtain high statistical efficiency. Deeper architectures also permit hierarchical representations. Deep learning is inspired from the architecture of brain. Brain simulations are used to make algorithms better and easier. With the availability of more advance and fast computers it is possible to design large neural networks and train them with myriad amounts of data. There can also be seen a high increase in the performance. Due to this capability, it’s been used in various fields like text, speech, images etc. Natural language process has started to being impacted by the deep learning techniques.

DL is a special kind of machine learning technique that achieves great power and flexibility by learning process to represent the world as nested hierarchy of concepts, with each concept defined in relation to simpler concepts, and more abstract representations computed in terms of less abstract ones.

DL allows computational models that are composed of multiple processing layers to learn representations of data with multiple levels of abstraction. These methods have dramatically improved the state-of-the-art in speech recognition, visual object recognition, object detection and many other domains such as drug discovery and genomics. Deep learning discovers intricate structure in large data sets by using the back-propagation algorithm to indicate how a machine should change its internal parameters that are used to compute the representation in each layer from the representation in the previous layer. Deep convolutional nets have brought about breakthroughs in processing images, video, speech and audio, whereas recurrent nets have shone light on sequential data such as text and speech. Due to this capability, it’s been used in various fields like text, speech, images etc. Natural language processing (NLP) has started to being impacted by the deep learning techniques.

Deep learning algorithms heavily depend on high-end machines, contrary to traditional machine learning algorithms, which can work on low-end machines. This is because the requirements of deep learning algorithm include Graphics Processing Units (GPUs) which are an integral part of its working principle.

In recent years, many Internet of Things (IoT) applications arise in different vertical domains, like health, transportation, smart home, smart city, agriculture, education, etc. The main element of most of these applications is an intelligent learning mechanism for prediction (regression, classification, and clustering), data mining and pattern recognition or data analytics in general. Among the many machine learning approaches, Deep Learning (DL) has been actively utilized in many IoT applications in recent years.

The most important difference between deep learning and traditional machine learning is its performance as the scale of data increases. When the data is small, deep learning algorithms don’t perform that well. This is because deep learning algorithms need a large amount of data to understand it perfectly.

The algorithms in deep learning or deep neural networks (DNN) are concerned with the functioning of the human brain and its structure.  DNN is a type of neural network having more than two layers. This type of neural network needs more data as well as the computational power to derive results.

**5. Advantages of Deep Learning**

Deep Learning helps in solving certain complex problems with high speed which were earlier left unsolved. Deep Learning is very useful in today’s real world applications. Following are some of the main advantages of deep learning.

* **Eliminates unnecessary costs** – Deep Learning helps to eliminate unnecessary costs by detecting defects and errors in the system.
* **Identifies defects which otherwise are difficult to detect –** Deep Learning helps in identifying defects which left untraceable in the system.
* **Can inspect irregular shapes and patterns –** Deep Learning can inspect irregular shapes and patterns which is difficult for machine learning to detect.

**6. Applications of Machine Learning andDeep Learning Techniques**

Some important domains and areas in AI where ML as well as DL has been applied are stated below:

**6.1 Automatic Speech Recognition (ASR)**

ASR system can be simply defined as a system that can translate a speech signal to its corresponding textual version. Currently, ASR is one of the best research areas that explored DL with high expectation. As we know that Google has announced that Google voice search had taken a new turn by adopting Deep Neural Networks (DNN) as the core technology used to model the sounds of a language in 2012 [1]. DNN also replaced Gaussian Mixture Model (GMM) which has been in the industry for 30 years till date. DNN also has proved that it is better able to measure which sound a user is fabricating at every instant in time and with this they delivered prominently increased the accuracy of speech recognition and speaker recognition. In 2013, DL has gained full momentum in both ASR and ML [2]. DL is basically linked to the use of multiple layers of nonlinear transformations to derive speech features, while learning with shallow layers comprises the use of exemplar-based representations for speech features which have high dimensionality but typically vacant entries.

**6.2 Speaker Recognition (SR)**

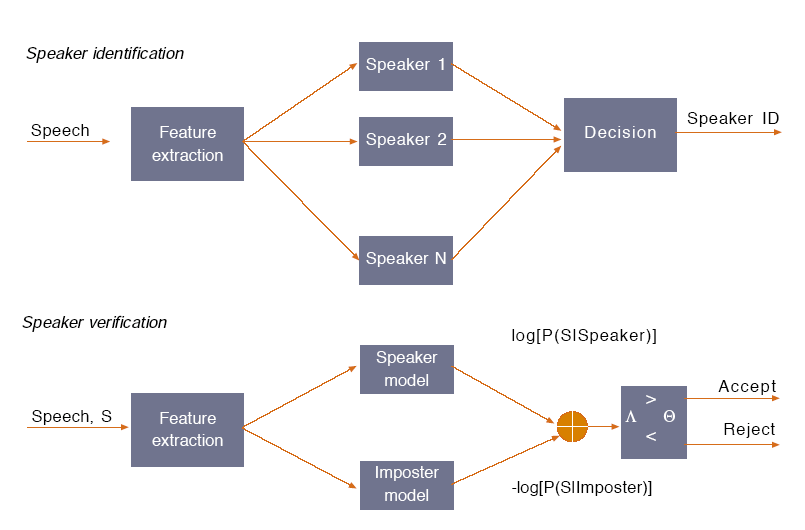
Speaker recognition [5] is an important bio-feature recognition method. It is the task of recognizing the identity of someone based on the speaker’s speech signal. Speaker recognition is a valuable biometric recognition technology and this method has been applied in several fields such as secure access to highly secure areas, machines such as voice dialing, banking, database, and computers. Due to the unique characteristics of speech signal, speaker recognition has drawn increasing attention from researchers in broad fields of information security for many years.

Speaker recognition study can be considered as the use of employing statistical methods to identify the individuals based on their unique acoustic properties, which are encoded in a sequence of successive samples in time. According to actual application, speaker recognition can be divided into two modes: Speaker verification and speaker identification [6, 7 ,8].

The research on speaker recognition can be dated back to at least 1960s [9]. In the following forty years, many advanced technologies promoted the development of speaker recognition.

For example, a number of acoustic features (e.g. the linear predictive cepstral coefficients, the perceptual linear prediction co- efficient, and the mel-frequency cepstral coefficients) and template models (e.g. vector quantization and dynamic time warping) have been applied [5]. Later on, [10] proposed the Gaussian mixture model based universal background model (GMM-UBM), which has been the foundation of speaker recognition for more than ten years since year 2000. Several representative models based on GMM-UBM have been developed, including the applications of support vector machines [11] and joint factor analysis [12]. Among the models, the GMM-UBM/i-vector frontend [13] with probabilistic linear discriminant analysis (PLDA) backend [14, 15] provided the state-of- the-art performance for several years, until the new era of deep learning based speaker recognition.

Recently, motivated by the powerful feature extraction capability of deep neural networks (DNNs), a lot of deep learning based speaker recognition methods were proposed [16, 17, 18] right after the great success of deep learning based speech recognition, which significantly boosts the performance of speaker recognition to a new level, even in wild environments [19, 20].

Fig1. Speaker Recognition System

The former study focuses on whether the claimed speaker is the true speaker, while the Speaker identification is the task of determining an unknown speaker’s identity by their speech signal.It is a 1:N match processing in which the extracted feature is compared against multiple templates [9]. In the speaker identification process [10], extracting speaker features from speech signals is a pivotal task. Human speech signals are a powerful medium of communication that contains rich information, such as gender, emotional traits, accent, etc. These unique characteristics enable researchers to identify speakers by voiceprint recognition [11]. The collected speaker utterances are fed into the deep learning network for training. In the recognition process, the speaker identification system matches the extracted speaker features with those in the model library. Then, the speaker with thehighest probability of utterance is identified as the target speaker. However, the stability of speaker identification is not enough. The recognition depends on the length of the voice, the voice collection environment, and the physical condition of the speaker. In addition, the recognition performance is generally not satisfactory in a noisy environment.

**6.3 Image Recognition (IR)**

Image Recognition is also an important research domain of image processing where DL techniques can be applied. As we know that Mitosis detection is very hard. In fact, mitosis is a complex process during which a cell nucleus undergoes various transformations. Deep max-pooling convolutional neural networks are used to detect mitosis in breast histology images was presented in [3]. In this approach, DNN as powerful pixel classifier is used which operates on raw pixel values and it does not require human input. Hence, DNN automatically learns a set of visual features from the training data. DNN is tested on a publicly available dataset and significantly outperforms all competing techniques, with manageable computational effortlike processing a 4MPixel image requires few minutes on a standard laptop. Large and deep convolutional neural network is trained to classify the 1.2 million high- resolution images in the ImageNet LSVRC-2010 contest into 1000 different classes [4].

**6.4 Natural Language Processing (NLP)**

Natural Language Processing or NLP is a branch of Artificial Intelligence using which computers are made to understand, manipulate, and interpret human language. It aims to fill the space between human communication and computer understanding. It is another interesting research domain in machine learning.It uses the concept of machine learning and deep learning for complete interaction between humans and computers.

Recently, deep learning methods have been successfully applied to a variety of language and information retrieval applications and language identification (LID). By exploiting deep architectures, deep learning techniques are able to discover from training data the hidden structures and features at different levels of abstractions useful for different tasks. In 2013, [21] proposed a series of Deep Structured Semantic Models (DSSM) for Web search. More specifically, they have used a DNN to rank a set of documents for a given query. First, a non-linear projection is performed to map the query and the documents to a common semantic space. Then, the relevance of each document given the query is calculated as the cosine similarity between their vectors in that semantic space. The neural network models are discriminatively trained using the click-through data such that the conditional likelihood of the clicked document is maximized. The new models are evaluated on a Web document rankingtask using a real-world data set. Results show that the proposed model significantly outperforms other latent semantic models, which were considered state-of-the-art in the performance prior to the work presented in [21].

**6.5 Drug Discovery and Toxicology (DDT)**

Quantitative Structure Analysis/Prediction Studies (QSAR/QSPR) attempt to build mathematical models relating physical and chemical properties of compounds to their chemical structure. In [22], multi-task learning is applied to QSAR using various neural network models. They used an artificial neural network to learn a function that predicts activities of compounds for multiple assays at the same time. The method is compared with alternative methods and reported that the neural nets with multi-tasking can lead to significantly improved results over baselines generated with random forests. In 2015, AtomNet has been introduced as first structure-based, deep convolutional neural network which designed to predict the bioactivity of small molecules for drug discovery applications [23].

**6.6 Customer Relationship Management (CRM)**

A framework for autonomous control of a customer relationship management system has been charted in [24]. First, a modified version of the widely accepted Recency-Frequency- Monetary Value system of metrics which can be used to define the state space of clients or donors is explored. Second, a procedure to determine the optimal direct marketing action in discrete and continuous action space for the given individual is described based on his position in the state space. The procedure involves the use of model-free Q-learning to train a deep neural network that relates a client's position in the state space to rewards associated with possible marketing activities. The estimated value function over the client state space can be interpreted as customer lifetime value (CLV), and thus allows for a quick plug-in estimation of CLV for a given client. Experimental results are presented, based on Knowledge Discovery and Data Mining Tools Competition, mailing dataset of donation solicitations.

**6.7 Recommendation Systems (RS)**

Automatic music recommendation has become an increasingly relevant problem in recent years, since a lot of music is now sold and consumed digitally. Most recommender systems rely on collaborative filtering. In 2013, it was proposed to use a latent factor model for recommendation, and predict the latent factors from music audio when they cannot be obtained from usage data [25]. Traditional approach is compared using a bag-of-words representation of the audio signals with deep convolutional neural networks, and the predictions are evaluated by quantitatively and qualitatively on the Million Song Dataset. The result shows that the recent advances in DL translate very well to the music recommendation setting, with deep convolutional neural networks significantly outperforming the traditional approach.Recent online services rely heavily on automatic personalization to recommend relevant content to a large number of users. This requires systems to scale promptly to accommodate the stream of new users visiting the online services for the first time. Work by [26] in 2015 proposed a content-based recommendation system to address both the recommendation quality and the system scalability. They also proposed to use a rich feature set to represent users, according to their web browsing history and search queries. They use a DL approach to map users and items to a latent space where the similarity between users and their preferred items is maximized. Scalability analysis shows that the multi-view DNN model can easily scale to encompass millions of users and billions of item entries.

**6.8 Bioinformatics**

Bioinformatics term is a combination of two terms bio and informatics. Bio means related to biology and informatics means information. Thus bioinformatics is a field that deals with processing and understanding of biological data using computational and statistical approach. Machine Learning has a number of applications in the area of bioinformatics. The annotation of genomic information is a major challenge in biology and bioinformatics. Existing databases of known gene functions are incomplete and prone to errors, and the bimolecular experiments needed to improve these databases are slow and costly. While computational methods are not a substitute for experimental verification.They can help in two ways: algorithms can aid in the curation of gene annotations by automatically suggesting inaccuracies, and they can predict previously-unidentified gene functions, accelerating the rate of gene function discovery. In [27], an algorithm that achieves both goals using deep auto encoder neural networks is developed. With experiments on gene annotation data from the Gene Ontology project, it shows that deep auto encoder networks achieve better performance than other standard machine learning methods, including the popular truncated singular value decomposition.

**7. Limitations of Deep Learning Technique**

There are also some limitations of deep learning techniques which are stated below:

* DL needs a large amount of data to extract results of experiments.
* Substantial computational power and resources are required by deep neural networks.
* Deep Learning is a time-consuming process.
* Training is to be provided so as to enable deep learning to make decisions.
* A high-performance computing environment is required for deep learning.

**8. Conclusion**

Machine Learning is one of the most popular and innovative area that quickly growing in computer science. Deep Learning is the extended form of ML. As ML and DL can solve lots innovative problems which are too difficult or time consuming as well as impossible for humans to solve, they are applied in nearly every other field of study and applications are already being implemented commercially. Like many other revolutionary technologies of the modern scientific age, recent development area of AI especially ML and DL are more feasible, efficient and precise than ever before. Powered by data science, ML makes our lives easier. Understanding the possibilities and recent innovations of ML as well as DL for businesses, they can plot a course for the most efficient ways of conducting their business.

**References**

[1] H. Sak, A. Senior, K. Rao, F. Beaufays and J.Schalkwyk (**2015**): Google voice search: faster and more accurate.

[2] L. Deng & X. Li, Machine learning paradigms for speech recognition: An overview. *IEEE Transactions on Audio, Speech, and Language Processing*, (**2013)** 21(5), pp.1060-1089.

[3] D. C. Ciresan, A.Giusti, , L. M.Gambardella, , & J. Schmidhuber, Mitosis detection in breast cancer histology images with deep neural networks. In *International Conference on Medical Image Computing and Computer-assisted Intervention* (**2013**, September).pp. 411-418.

[4] A.Krizhevsky, I. Sutskever& G.E. Hinton, Imagenet classification with deep convolutional neural networks. I*n Advances in neural information processing systems***(2012)**.pp. 1097- 1105

[5] T. Kinnunen, H. Li, An overview of text-independent speaker recognition: From features to supervectors, *Speech communication* 52 (1) (**2010**) 12–40.

[6] J. P. Campbell, W. Shen, W. M. Campbell, R. Schwartz, J.-F.Bonastre, D. Matrouf, Forensic speaker recognition, *IEEE Signal Processing Magazine* 26 (2) (**2009**) pp.95–103.

[7] C. Champod, D. Meuwly, The inference of identity in forensic speaker recognition, *Speech communication* 31 (2-3) (**2000**) pp.193–203.

[8] R. Togneri, D. Pullella, An overview of speaker identification: Accuracy and robustness issues, *IEEE circuits and systems magazine* 11 (2) (**2011**),pp. 23–61.

[9] S. Pruzansky, M. V. Mathews, Talker-recognition procedure based on analysis of variance, *The Journal of the Acoustical Society of America* 36 (11) (**1964**) pp.2041–2047.

[10] D. A. Reynolds, T. F. Quatieri, R. B. Dunn, Speaker verification using adapted gaussian mixture models, *Digital signal processing* 10 (1-3) (**2000**) pp.19–41.

[11] W. M. Campbell, D. E. Sturim, D. A. Reynolds, Support vector machines using GMM supervectors for speaker verification, *IEEE signal processing letters* 13 (5) (**2006**) pp.308–311.

[12] P. Kenny, G. Boulianne, P. Ouellet, P. Dumouchel, Joint factor analysis versus eigenchannels in speaker recognition, *IEEE Transactions on Audio, Speech, and Language Processing* 15 (4) (**2007**) pp.1435–1447.

[13] N. Dehak, P. J. Kenny, R. Dehak, P. Dumouchel, P. Ouellet, Front-end factor analysis for speaker verification, *IEEE Transactions on Audio, Speech, and Language Processing* 19 (4) (**2010**) pp.788–798.

[14] P. Kenny, Bayesian speaker verification with heavy-tailed priors., in: *Odyssey,* Vol. 14, **2010.**

[15] D. Garcia-Romero, C. Y. Espy-Wilson, Analysis of i-vector length normalization in speaker recognition systems, in: *Twelfth annual conference of the international speech communication association,***2011**.

[16] Y. Lei, N. Scheffer, L. Ferrer, M. McLaren, A novel scheme for speaker recognition using a phonetically-aware deep neural network, in: *IEEE International Conference on Acoustics, Speech and Signal Processing (ICASSP),* IEEE, **2014**, pp. 1695–1699.

[17] E. Variani, X. Lei, E. McDermott, I. L. Moreno, J. Gonzalez Dominguez, Deep neural networks for small footprint text-dependent speaker verification, in: 2014 *IEEE International Conference on Acoustics, Speech and Signal Processing (ICASSP),* IEEE, **2014,** pp. 4052– 4056.

[18] D. Snyder, D. Garcia-Romero, G. Sell, D. Povey, S. Khudanpur, X- vectors: Robust DNN embeddings for speaker recognition, in: 2018 *IEEE International Conference on Acoustics, Speech and Signal Processing (ICASSP)*, IEEE, **2018,** pp. 5329–5333.

[19] A. Nagrani, J. S. Chung, A. Zisserman, VoxCeleb: A large-scale speaker identification dataset, *Proc. Interspeech 2017* (**2017**) pp.2616–2620.

[20] M. McLaren, L. Ferrer, D. Castan, A. Lawson, The speakers in the wild (SITW) speaker recognition database., *in: Interspeech*, **2016**, pp. 818–822.

[21] P. S.Huang, , X. He, J. Gao, L.Deng, , A. Acero, , & L. Heck, Learning deep structured semantic models for web search using clickthrough data. In *Proceedings of the 22nd ACM international conference on Conference on information & knowledge management* (**2013**, October).pp. 2333- 2338.ACM.

[22] G. E. Dahl, ,N.Jaitly, , &R.Salakhutdinov, Multi-task neural networks for QSAR predictions. arXiv preprint arXiv:1406.1231.**(2014).**

[23] I.Wallach, M. Dzamba, & A. Heifets, AtomNet: A Deep Convolutional Neural Network for Bioactivity Prediction in Structure-based Drug Discovery. arXiv preprint arXiv:1510.02855.**(2015)**.

[24] Y. Tkachenko, Autonomous CRM Control via CLV Approximation with Deep Reinforcement Learning in Discrete and Continuous Action Space. arXiv preprint arXiv:1504.01840.(**2015)**.

[25] A.Van den Oord, S.Dieleman, & B. Schrauwen, Deep content-based music recommendation. In *Advances in Neural Information Processing Systems* (**2013) ,**pp. 2643-2651.

[26] A.M.Elkahky, Y. Song, &X.He, A multi-view deep learning approach for cross domain user modeling in recommendation systems. In *Proceedings of the 24th International Conference on World Wide Web*.(**2015,** May).pp. 278-288.ACM.

[27] D.Chicco, ,P.Sadowski , &P. Baldi, Deep autoencoder neural networks for gene ontology annotation predictions. In *Proceedings of the 5th ACM Conference on Bioinformatics, Computational Biology, and Health Informatics* (**2014,** September). pp. 533-540. ACM.