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Deep Learning Architectures in Language Learning: A Paradigm for Change

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Abstract

Along with the unprecedented developments regarding all dimensions of education systems, successful implementation of technology-based pedagogic interventions would be of great interest. One of the major areas of progress deals with the essential qualities of the deep neural network in the various domains of research as well as science, which is fundamentally built to imitate the activity of the human brain, including cognitive, affective, social and emotional factors. Undoubtedly, great attention should be paid to the feasibility of implementation of the varieties of deep learning architectures in language learning environments, which can be assessed. In this paper, deep learning architectures are examined to study the architectures, aspects, and models regarding deep language learning in order to improve the performance of learners of English as a foreign language. The general stages of any dynamic modeling approach include selecting a mathematical model for a physical problem, developing the model and finally providing its solution to describe the basic components and theoretical background conducing to the emergence of a new paradigm in the context of language learning. Considering the deep learning architectures of Deep Convolution Neural Network (DCNN), and Recurrent Neural Network (RNN), aspects of language learning were examined. The survey necessitates implementing a neurophysiological paradigm embracing all learning requirements.

Keywords: Deep learning, Language learning.

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1. Introduction

The advent of Deep Learning has triggered a significant impact on many areas of science and technology by dramatically improving the depth and expansion of the observations and findings. Furthermore, deep neural models including Deep Neural Networks (DNNs) [1] and Convolutional Neural Networks (CNNs) have led to many practical applications by outperforming traditional methods used in educational systems. In recent years numerous researchers have explored the use of learning strategies and algorithms as key components to facilitate implementation of various natural language processing tasks. Basically, Neural Networks and Deep Learning Neural networks are composed of a set of interconnected nodes, or neurons, each receiving some number of inputs and outputs. The main distinguishing factors of different types of networks are how of connection of the nodes and the number of layers. To put it in a simple way, as there is no comprehensive consensus on the definition of the deep neural network (DNN), networks with multiple hidden layers are regarded as deep and those with many layers are defined as very deep networks [2].

On the other hand, language learning has always been an important research issue in both linguistics and cognitive science encompassing different aspects and variables as well. For instance, there was a great amount of research on reading, grammar, writing, speaking and vocabulary learning required for language proficiency. As these numerous studies represent language complexity, it stresses the importance of learning and acquiring the adequate proficiency in this regard. Furthermore, it is discovered about language learning research that there is neither an absolute structure in the brain that corresponds to a Language Acquisition Device as argued by Chomsky and others, nor a totally human genetic innovation, as its central aspects emerges through evolutionary processes of neural systems [3]. As proposed by Plunket and Elman (1997), language learning occurs via the same general processes as other cognitive skills, taking grammar as a matter of highly structured neural connections. However, little existing studies have embraced both significant concepts of language learning and deep learning architectures into a comprehensive study [4].

Taking both language learning and neural network manipulating in human mind, the previously-conducted studies are regarded as using experimental data or mathematical model data alone; but using both experimental data and mathematical model data to track the influential ones at a given time has been less studied, which in these cases the model updating is mostly based on real observed data and real reported data. On this basis, the paper aims to present the variety of deep neural network architectures utilizing in various learning methods relevant to the aspects of language learning including speech recognition, image recognition, the natural language processing and the other applications respectively.

2. Deep Learning

The high demand of exploring and analyzing large amount of data has arisen the use of machine learning algorithm called deep learning (DL). As a subcategory of machine learning, deep learning follows the human instincts of learning to produce fruitful results. Being conceived in 1980s, it turned into the predominant approach in the recent years. Deep Learning has gained huge success in a wide range of applications such as computer games, speech recognition, computer vision, medical research natural language processing, self-driving cars and consumer electronics [5]. As a key role in solving various items, the most recent application would be the utilization of the cloud computing with unique advantages of increased amounts of data representation and the continuous increase of available computer power respectively [6].

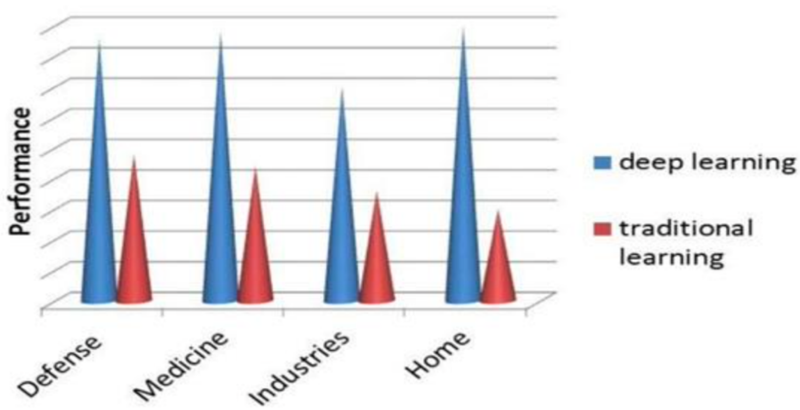

Figure1. Performance of deep learning.

Practically speaking, in order to classify a data set, many of the deep learning techniques implement the neural network architectures. In this regard, the word deep refers to the number of hidden layers, unlike traditional neural networks with two or three hidden layers; while the deep neural network can hold more than hundred and fifty hidden layers, thus, it can directly learn the features from the data itself. The Figure 2 shows the difference between the deep learning and traditional learning in terms of categorizing an object. Where the Figure 2 (a) Is the classification using the traditional learning method and the (b) represents the deep learning method that automatically learns from the data set [7].

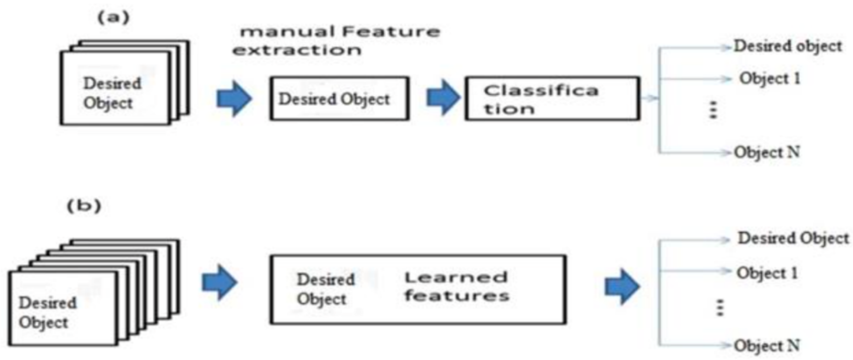

Figure 2. (a) Traditional learning, (b) Deep learning.

3. Neural Network Structure

Theoretically, neural network is defined as a model to simulate the function of human brain nervous system, which has modeled and connected neurons as the basic unit of human brain, resulting in an artificial system with intelligent information processing including learning, association, memory, and pattern recognition. Any neural network can learn from the environment and store the learning results in the synaptic connections of the network, taken as a process [8]. A common neural network structure is called full connection layer [9]. Using the facets of the artificial intelligence to classify and order the data, neural network can solve complex problems better. Common activation functions include Sigmoid function, Tanh function, and ReLU function [10]. Various deep learning architectures, such as Deep Convolution Neural Networks (DCNN), Deep Belief Networks (DBN) and Deep Auto-Encoders (DAE) have been examined to determine their roles in language learning and extract the features from them.

3.1 Deep Convolution Neural Networks (DCNN)

One of the most common and popular deep neural networks used in a broader range of applications is called the convolution neural network which provides an automated way of extracting the feature by direct learning the features from the images or the text [7]. Basically, a developed Deep Convolutional Neural Network (DCNN) learns the features in parallel by training interference and customized architecture, as it learns from the frequency data to check the learning performance of different features from time data. In other words, it convolutes the input data and utilizes the two dimensional convolutional layers, eluding the necessity for the manual feature extraction by extracting the features directly from the images. This makes the DNN more compatible and suitable for the accurate classification of the objects [7], which is used extensively in image and video processing, speech and NLP [11].

3.2 Recurrent neural networks (RNNs)

As a different powerful approach to model sequential data in learning temporal structures from the input sequences, recurrent connections were proposed to enable parameters to be shared across time, hence prove their superiority over traditional HMM-based systems in a variety of speech and audio processing tasks [12]. Recently, these RNN models have been extended to include information in the frequency domain besides temporal information generating Frequency-LSTMs [13] and Time-Frequency LSTMs [14]. In order to benefit from both neural architectures, CNNs and RNNs can be combined into forming a single network with convolutional layers followed by recurrent layers, often referred to as "Convolutional Recurrent Neural Networks (CRNN)". Relevant works combining CNNs and RNNs can be mostly presented in music classification [15], and other audio related applications [12]. Additionally, Sequence-to-sequence (Seq2Seq) models were motivated due to problems requiring sequences of unknown lengths [16].

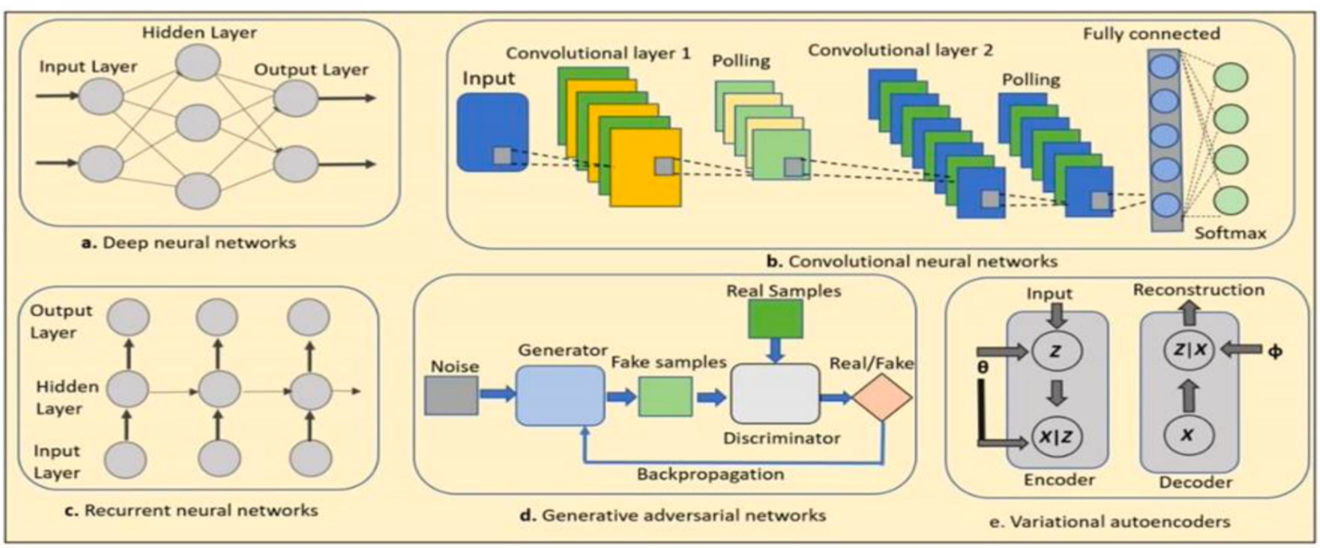

Figure 3. Different illustrations of DL architecture.

4. Aspects of Language Learning

Learning, as a dynamic process, is defined as acquiring and modifying knowledge, skills, strategies, attitudes, beliefs, and behaviors. There are different dominant perspectives regarding learning; for instance, from a cognitive neuroscience perspective, learning involves the forming and strengthening of neural connections, which are called synapses, a process known as consolidation. From a constructive view, people learn cognitive, linguistic, motor, and social skills, and these can take many forms, and neurologically, the interaction involving multiple structures of brain and synaptic connections is seen clearly in language learning. Taking memory as a key component of the information processing system, Learning, or encoding, occurs when information is stored in Long Term Memory.

As a review of the deep neural networks for the “speech recognition”, an optimized neural architecture was proposed to provide a better optimization and to enhance the compatibility of parameters of the deep neural network with the accurate ways of speech preprocessing. The time delay of developing the neural networks is viewed as the forerunner of the CNN. This ensures a long term temporal dependencies from the short term features extracted from the speech, allowing a lower layer of the network to get updated with the accumulated gradient every time step of the input temporal context during the back-propagation and a speedy training by selection of the sub-sampling indices effectively. As another very popular aspect of language learning is CNN, which is extensively used for “image recognition”, containing several convolution layers and subsampling layers. The convolution layer consists of a set of filters with small receptive field and learnable parameters. It has outperformed other types of machine learning algorithms in image recognition [17].

4.1 Models of Language Learning Regarding Neural Networks

As shown in Figure 4, the system organization of language learning includes three layers of the user layer, the business layer, and the data layer. The data layer stores data and ensures the reliability and security of data. According to the actual needs of the language learning system, the data layer takes the responsibility of user information database storage, vocabulary database, user log behavior database, user comment data, and test data. Next, the business layer realizes the core business logic of the recommendation system, including mining of the similar word and similar user, recommending words to learners through user-based collaborative filtering algorithm, positioning users’ learning style through algorithm of clustering, and adjusting push methods [18]. The user layer is responsible for the interaction between learners and the system, and data will be logged to the log database. The server responds to user requests and displays content results, such as word learning, information registration, corpus uploading, testing completion, and other functions.

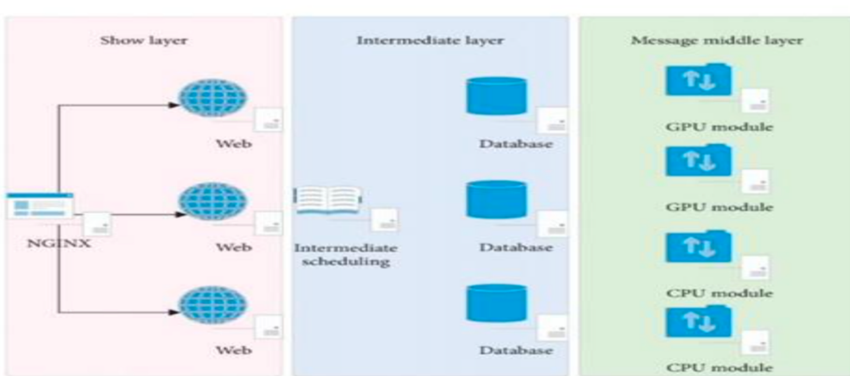

Figure 4. English learning model.

The other model proposed as Functional Flow Design, bears the core function of the learning software including word learning. In this regard, English learning is defined as a process that requires recording, feedback, and following up activities. When learning English, users can choose whether to highlight a new word, or comment on the word. As the cycle goes on, the number of new words in the users' vocabulary is increasing. The system can help users to quickly find new words when learning, improve the efficiency of memorizing words, and quickly expand the vocabulary. When the user is collecting the vocabulary, the system will automatically ask the user whether to remember the word as the core word. If not marked, the system will judge whether the word belongs to proper nouns according to the characteristics of the word itself.

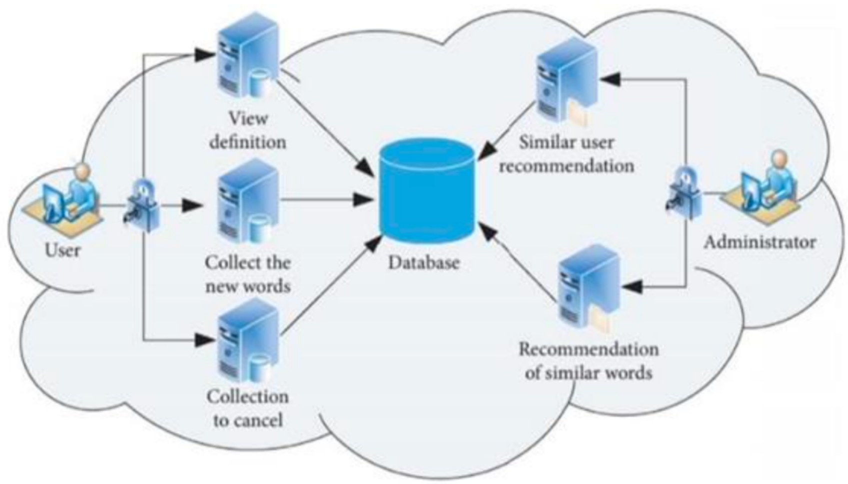

Figure 5. Functional flowchart.

5. Concluding Remarks

In the process of moving SLA theory onto a firm grounding model that takes into consideration the neural network approach, we have just reviewed the overlapping influential domains across the neural network architectures and the neurophysiological language learning models, the need to create a more comprehensive paradigm that covers all aspects of language learning in the neural system of mind seems essential. A neurological-based language learning paradigm would resolve many of the complexities and have significant application to language teaching which can create a more realistic and useful basis for research and practice. So the future research studies would be directed to proceed with the utilization of the deep neural network in language learning field demonstrating as the software, applications and chips, accompanied with the analysis of the deep neural network efficiencies when integrated with the cloud computing.

The proposed language learning paradigm would also revolutionize the way we attempt to teach languages in classrooms. Teachers, syllabus designers and curriculum providers are supposed to take into account the neurological basis of language learning system as well.

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