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Application of Neural Network's Modeling for Improvement of Children's Reading Brain Performance (A Case Study Assessment)

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Abstract

Overwhelming majority of neurobiologists' research efforts has recently revealed findings about common increasingly sophisticated role adopted by Artificial Neural Networks (ANN^S). This role applied commonly for systematic realistic modeling of interdisciplinary disciplines incorporating neuroscience, education, and cognitive sciences. Accordingly, ANN^S Models vary in relation to the nature of assigned brain function to be modeled. For example, as human learning that takes place autonomously according to received stimuli that are realistically simulated through self-organization modeling. This piece of research adopts the conceptual approach of ANN^S models inspired by functioning of highly specialized biological neurons in reading brain based on the organization the brain's structures/substructures. Additionally, in accordance with the prevailing concept of individual intrinsic characterized properties of highly specialized neurons, presented models closely correspond to performance of these neurons for developing reading brain in a significant way. More specifically, introduced models concerned with their important role played in carrying out cognitive brain function' outcomes. The cognitive goal for reading brain is to translate that orthographic word-from into a spoken word (phonological word-form). In this context presented work herein, reveals via ANN simulation results: How a set of highly specialized neurons could be dynamically involved in performing development of cognitive reading brain function. More precisely, the objective of adopted simulation approach is to reveal how a group of tiny individual specialized neurons are capable to work cooperatively together in order to produce an intellectual-like behavioral learning to read, that exhibits proper cognitive decoding of orthographic word-form into phonological word-form. Interestingly, obtained results of presented case study (at some elementary school) shown to be in well agreement with obtained ANN simulation results

1. Introduction

Performed tasks by human brain are commonly tightly coupled to the two main brain functions. These are: learning that defined as brain's ability to modify behavior in response to stored experience (inside brain synaptic interconnections), and memory is that capability to store that modification (information) over a period of time as well as to retrieve spontaneously modified experienced (learned) patterns i.e. Pattern Recognition. Based on neural network modeling, mutual tight relation between learning and memory brain functions has been illustrated at some recently published work [1][2]. In nature, the working memory components contribute to development of a functional system for a reading brain. Accordingly, reading process in human brain performed as decoding process transferring written (seen) orthographic word-from into pronounced (spoken) phonological word-form. More precisely, reading brain process viewed to be performed by brain moment our eyes fall on depicted written orthographic word-form, a complex set of physical, neurological, and cognitive processes is originated [3][4]. In the context of artificial neural network (*ANN*) modeling to accomplish decoding (transferring) of seen signals into pronounced (spoken) word-form belongs to Pattern recognition paradigm. Furthermore, in the context of reading brain, an investigational cognitive modeling approach to evaluate phonics method applied for teaching children how to read. It considered the assessment process performed using a biologically (naturally) inspired by an artificial neural network (*ANN*) model. That model considers associative brain function, between two visual (orthographic word-from) and audible signals *(phonological word-form)* that published at [5][6]. These publications have been motivated by a challenging educational issue titled: "how to learn reading?" which announced -before two decades- by the great debate at [9], and during last decade as well at [7][8].Very recently, interesting ANN simulation results illustrated how sets of highly specialized neurons' number can perform the cognitive function of developing reading brain [9]. Herein, ANN^S Models have been adopted to perform realistic simulation of both principles concerned with learning role of how reading could be performed by the brain. In more details, ANN^S are computational systems which are increasingly common and sophisticated. Computational scientists who work with such systems

however, often assume that they are simplistic versions of the neural systems within our brains and [10][11] has gone further in proposing that human learning takes place through the self-organization of such however, artificial neural networks were originally conceived of in relation to how systems according to the stimuli they receive. ANN^s are mathematical models inspired by the organization and functioning of biological neurons. There are numerous artificial neural network variations that are related to the nature of the task assigned to the network. There are also numerous variations in how the neuron is modeled. In some cases, these models correspond closely to biological neurons [12][13] in other cases the models depart from biological functioning in significant ways.

2. Description of Reading Model System

Mainly reading brain function, concerned with carrying out the associative memory originated by working part of brain memory. The associative function implies that children must be able to code orthographically written words and letters. The reading goal is performed via association (translation) of orthographic word-from code into a spoken word (phonological word-form code) [10]. In other words, the visually recognized written (code) pattern should be transferred and pronounced in accordance with its associated code as correspondingly correlated auditory code pattern which has been stored previously into working memory [4]. Referring to (Fig.2&Fig.3), suggested models obeys that concept as the two inputs I_1, I_2 represent sound (heard) stimulus which simulates *phonological word-form* and visual (sight) stimulus which simulates *orthographic word-from* respectively. The post processed outputs O_1, O_2 are corresponded to reading and dictating (writing) processes respectively. It is worthy to note in accordance with autonomous learning paradigm the suggested model obeys the original Hebbian learning rule [14]. As the children perform their reading tasks based on previously learned lessons former experienced acquired knowledge. Furthermore, the simulated reading process following that model is analogously straight forward to the Pavlovian conditioning learning [14][15]. The input stimuli to the model are considered to be either conditioned or unconditioned stimuli. Visual and audible signals are developed for training (interchangeably) as model's inputs to obtain desired (post processed) output model's responses. Moreover the model obeys more elaborate mathematical analysis for Pavlovian learning process [16]. Also, the model is modified following general Hebbian algorithm (GHA) and correlation matrix memory [2][17][18][19]. The adopted model is designed basically following after simulation of the previously measured performance of classical conditioning experiments. The model design concept is presented after the mathematical transformation of some biological hypotheses. In fact, these hypotheses are derived according to cognitive/ behavioral tasks observed during the experimental learning process. The below simple structure at Fig. 2 drives an output response reading function (pronouncing) that is represented as O_1. However the other output response represented as O_2 is obtained when input sound is considered as conditioned stimulus. Hence visual recognition as condition response of the heard letter/ word is obtained as output O_2. In the context of neurobiology, the strength of response signal is dependent upon the transfer properties of the output motor neuron stimulating salivation gland. Lettered circles A, B, C, and D represent a neuron cell body. However, lines connecting cell bodies are denoted by synaptic junctions Wij between neuron (i) and neuron (j) .The output signals released out from sensory sound and sight neurons A and C are represented by y_1 and y_2 respectively.

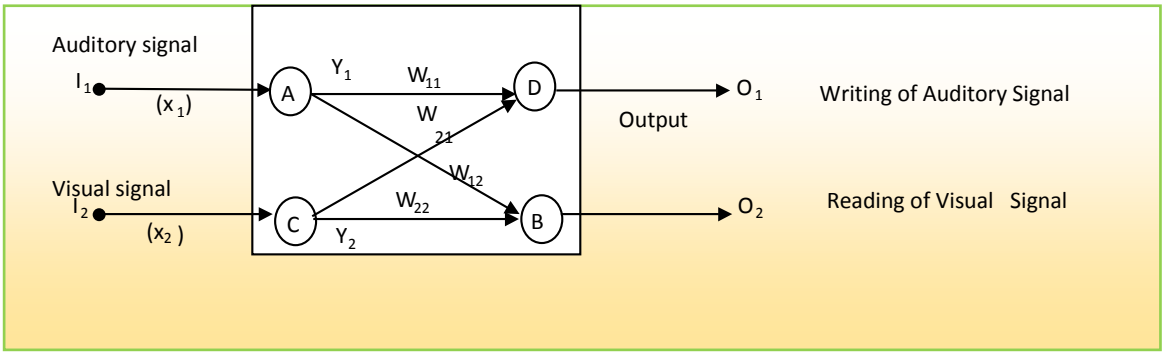

Figure 1. Generalized reading model which predented as pronouncing of some word (s) considering input stimuli and output responses.

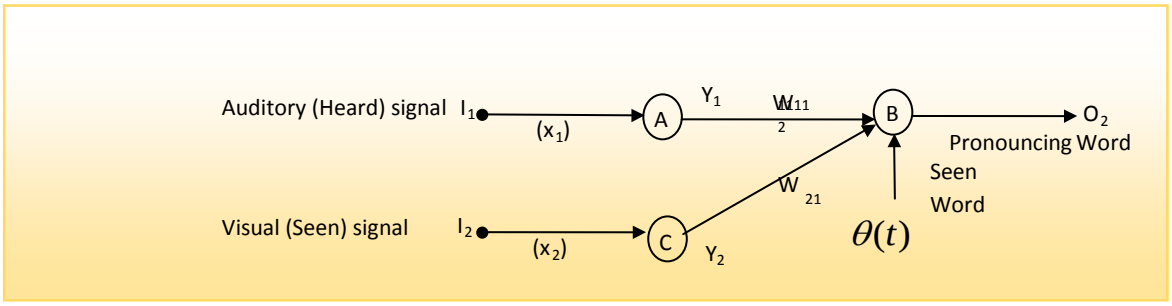

Figure 2. The structure of the first model where reading process is expressed by conditioned response for seen letter/ word (adapted from [28])

3. Practical and Simulation Results

Obtained practical educational results of suggested case study given at subsection 3.1, have been obtained after field experimental tests performed at the Safa private schools at the East Province in Kingdom of Saudi Arabia. Interestingly, obtained experimental results shown to be in well agreement with the other ANN simulation results introduced at subsection 3.2.

3.1 Practical Assessment Results for the Case Study

This subsection illustrates the assessment of observed individual difference phenomenon in our children's classrooms. That assessment is measured after evaluation of response time required to recognize the heard word by each child individually. The observed recognition (response) time measured in Sec. is mapped to get the corresponding outcome measured in marks.

Table.1 Illustrates the resulting relation between recognition (Time Response) and the mapped mark values

Students	Outcomes After Classical Teaching	Time Response Considering Classical Group
1	4.2	493
2	67.6	333
3	17.7	459
4	78.7	305
5	4.6	492
6	34.7	416
7	76.7	310
8	20.1	478
9	10.2	310
10	41.1	400
11	5	491
12	75.9	312

Table.2 Illustrates statistical analysis of above obtained case study results (Time Response)

SUM of total Students' time response (Sec.)	Mean of Time Response (Sec.) M	Variance σ	Standard deviation $\sqrt{\sigma}$	Coefficient of variation $\{\rho = \sqrt{\sigma} / M\}$
5776	**412.57**	**5178.24**	**71.96**	**0.17**

Table.3 Illustrates statistical analysis of above obtained case study results (Recognition Achievement)

Sum of total Students' outcomes score (Marks)	Mean of total Students' outcomes (Marks) M [%]	Variance σ	Standard deviation $\sqrt{\sigma}$	Coefficient of variation $\{\rho = \sqrt{\sigma} / M\}$
505.1	**36.08**	**812.82**	**28.51**	**0.79**

3.2 Simulation Results

At educational field practice, different applied teaching procedures (methodologies) analogously straight forward to various learning rate values considered at ANN context. Accordingly, enhanced (improved) learning performance outcomes have been observed in case of application of a modified teaching methodology [20]. Additionally, interesting analysis of students' individual differences using ANN^S modeling has been introduced considering neural networks parameters at [21]. At Fig.3, the three depicted graphs present obtained simulation results supporting the relation between various learning rate values and learning performance considering different number of neurons. Herein, the observed diverse individual difference phenomenon in our classrooms considered on the basis of the different number of neurons contributing in performing the reading process. That adopted approach is illustrated at Fig3.

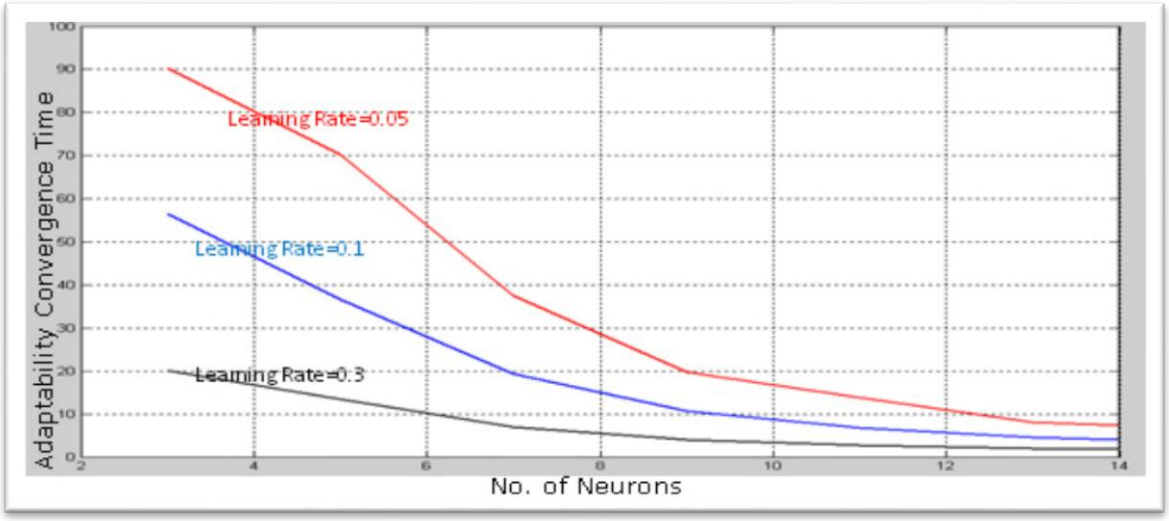

Fig.3 illustrates the performance of error correction algorithm versus learning convergence time for different learning rate values.

4. Conclusions

Herein, presented study introduces how highly specialized neurons could be dynamically simulated realistically. It shows that flock of highly specified reading neurons interacts together among the flock's agents (number of neurons) to perform a specific common role (Reading function) in accordance with diverse individual differences among children at their sensory brain areas. That reading process is performed via decoding of orthographic word-form {seen signal (visual)} into phonological word-form {heard signal (auditory)}. In future, more elaborate assessment (quantitative evaluation) of interdisciplinary individual differences phenomenon is highly recommended. In addition to perform more elaborate investigational analysis and evaluations for other cognitive behavioral learning phenomena such as learning creativity, improvement of learning performance, learning styles,……etc. using ANNs modeling.

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