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Physics of Neural Network and Unlimited Memories System in Spin Glass Regime Alloys

Dr. Muhammad Ahmad AL-Jalali*

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□ ABSTRACT □

Theoretical neural network model has been proposed, to simulate a model derived from theory of spin glass, which stress on hierarchical regime used in neural network and the genetic theory of generational succession and communication with each other. Hamiltonian energy has been adapted to comparison between the neural network and hierarchical regime in spin glass alloys. The study emphasizes that the computer which have boundless capacity and mimics the human brain, can be produced through the developing of this kinds of spin glass alloys.

Key Words: Spin Glass, neural network, hierarchical regime.
PACS: 75:50, 75:10, 75:40, 75:30.

***Physics department, faculty of science, Taif University, Kingdom of Saudi Arabia.**
E-mail:aljalali7@hotmail.

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فيزياء الشبكة العصبية ونظام الذاكرات اللامحدود في خلائط نظام الزجاج السبيني

الدكتور محمد أحمد آلجلالي*

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□ الملخّص □

تم اقتراح نموذج نظري للشبكة العصبية يحاكي النموذج المستنبط من نظرية الزجاج السبيني الذي يؤكد على النظام التفرعي المستخدم في الشبكة العصبية و في النظرية الوراثية لتعاقب الأجيال واتصالها مع بعضها البعض. وقد تم اعتماد هاملتون الطاقة للمقارنة بين الشبكة العصبية والنظام التفرعي في خلائط الزجاج السبيني ، تؤكد الدراسة على أن الحاسوب الذي سوف يتمتع بالسعة اللامحدودة ويحاكي الدماغ البشري سيكون عبر تطوير خلائط الزجاج السبيني.

الكلمات المفتاحية:الزجاج السبيني–الشبكة العصبية–النظام التفرعي.

PACS: 75:50, 75:10, 75:40, 75:30 .

Introduction:

* قسم الفيزياء– كلية العلوم – جامعة الطائف– المملكة العربية السعودية .

For the first time in the history of physics is the discovery of magnetic alloys [1] of a system mimics the behaviour of biological systems [2]. These alloys, called spin glass alloys, stunned experimentalists and theoreticians researchers through the pilot study of their behaviour under the influence of thermal or external magnetic fields. The aims and results of that researches on these alloys will help a huge sector of the researchers in brain, nerve network, proteins, nuclear acids involved in the installation of genes and even in the development of rubber industry, also in all materials that follow in one of their thermal stages the behaviour of glass viscosity.

Methodology and Material

we can divide this part to tow points:

a. Spin glass Hamiltonian:

The model EA (Edwards-Anderson) [3]is the first theoretical model describing the state of spin glass alloys, where the range of magnetic impurity concentrations in alloy, must be achieved at the border where only indirect exchange interactions between spins are fulfilled (indirect Ruderman - Kittel – Kasuya - Yoshida(RKKY) interactions) [4]. EA Hamiltonian is given as follows:

$$\mathbf{H} = \sum_{\langle i,j \rangle} J_{ij} S_i . S_j \qquad (1)$$

Where (S_i) spin at site i, (S_j) spin at site j, (J_{ij} exchange constant), and RKKY interactions energy is given by:

$$J(R_{ij}) = \frac{9\pi n^2}{E_F} J_{sd}^2 \frac{x\cos x - \sin x}{x^4} \qquad (2)$$

Where ($x = 2k_F R_{ij}$), { $J_{ij} = J(R_i - R_j) = J(R_{ij})$}

In the event of an external magnetic field, it will affect every spins (i) and the Hamiltonian becomes:

$$\mathbf{H} = \sum_{\langle i,j \rangle} J_{ij} S_i . S_j + h_i S_i \qquad (3)$$

EA model has described the system through an Order Parameter, carries memory qualities at freezing temperature (T_f) through the following relationship:

$$q_{EA}(t) = \langle S_i(t) . S_i(0) \rangle$$
$$when \quad T \le T_f \Rightarrow q_{EA} \neq 0$$
$$and\ when \quad T \ge T_f \Rightarrow q_{EA} = 0 \qquad (4)$$

According to this analysis {through magnetization ($M = \langle S_i \rangle$)) and the order parameter (q)} one can distinguish three models, namely:

1. Paramagnetic magnetic model where ($M = 0$ and $q = 0$).
2. Spin glass model where ($M = 0$ and $q \neq 0$).
3. Ferromagnetic model in which ($M \neq 0$ and $q \neq 0$).

and the relaxation time therefore has been studied to those alloys to confirm the memory character and retain information for a very long period of time through the use of Arrhenius law (AL) and a Vogel- Fulcher law (VFL)[5] in the study of viscosity and relaxation times of normal glass.

b. The proposed model for neural network Hamiltonian:

c.neuron is composed of the following major sections(Fig.1):

1. Cell body
2. Dendrites (ramifications of nerve cell).
3. Nervous axis (axon).

The information are fed through the dendrites of the first cell, after processing of these input information within the body of the cell, the output information are fed to the next cell across the axon through ramifications associated with the second neurological cell, this can be achieved through the so-called synaptic junctions.

Neuron will be effective (fires) if the total external stimuli at cell exceed what is called a threshold (step) .In the simplified case, neuron is represented as a system of two cases, the first is effective and the second is ineffective.

If the symbol of the state of the cell is (S_i) at the moment (t) where (S_i = +1) in the effective case and (S_i = -1) in the ineffective case, the symbol of the coupling energy (exchange of information) between two cells (i) and (j) is given by symbol (J_{ij}), then the total aggregate effects on the cell (i) from each other cell (j) is given by the relationship:

$$H_i = \sum J_{ij} S_j \qquad (5)$$

If the symbolic of threshold of the cell (i) has the symbol (T_i), the cell (i) will respond or not respond to stimuli, provided that the following relations will be verified:

$$s_i = +1 \quad if \quad \sum J_{ij} S_j > T_i$$
$$s_i = -1 \quad if \quad \sum J_{ij} S_j < T_i \qquad (6)$$

Compared with the Hamiltonian of spin glass eq.(1), we can write neural network Hamiltonian, as previously assumed, with the following relationship:

$$\mathbf{H} = \sum J_{ij} S_i S_j \qquad (7)$$

This relationship simulates in its mathematical figure the function of spin glass Hamiltonian. Based on this logic, the neural network will be treated from the perspective of the theory of spin glass, and this requires in-depth all the models(many and complex) based on that theory, and what concerns us here is the hierarchical regime for the biological or artificial nervous system .

In the event of an external field (h_i) on the cell (i) we add another term to the former Hamiltonian to become:

$$\mathbf{H} = \sum J_{ij} S_i S_j + h_i S_i \qquad (8)$$

The nervous synapsis points (Fig.1) can be in the case of irritant (effective) or in the case of stem (ineffective), and the competition between these two cases of interactions resembles the case of competition for the exchange interactions in the spin glass system (interaction between the two spins can give either the status of ferromagnetic or antiferromagnetic which called the state of frustration in the spin glass regime).

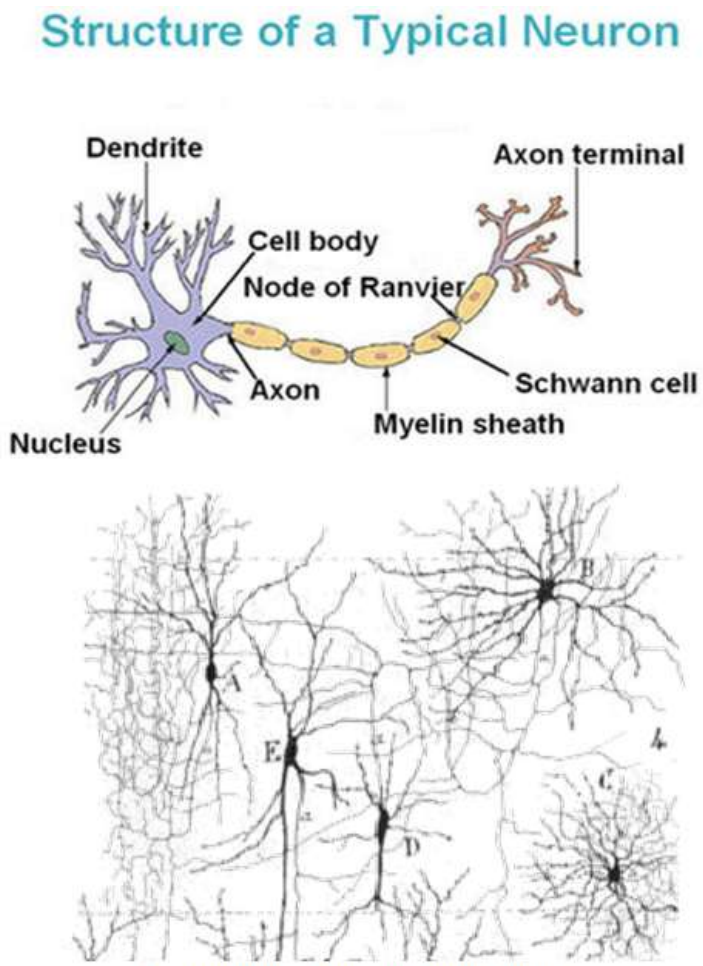

Fig.(1):neuron and nervous synapsis points

This treatment agrees with the Hopfield theory [6] of the neural network which considers that neurons an integrated system and the states (S_i) and (S_j) back to the same system. The neural network in accordance with that theory must possess a large storage capacity for learning and memorizing and then treats the issue of oblivion and behaviour .... etc.

This requires an expansion in the area of the physiology of the nerves (which is outside the scope of this research), that aims to simulate the neural network through physical system can mimics biological neural network depending on electrical pulse system, according to dynamical physical mechanism adopting a magnetic database system(human brain=magnetic hard disk).

Results and Discussion

A - Application of hierarchical regime at proposed model:

Through the cluster state (the tree trunk and branches, the brain , nerves, Grandfather and grandchildren), the hierarchical regime shows[7] that the order parameter q_{EA} can be circulated to all pure clusters (groupings) ,Because EA have taken only pure cases which is the final tree branches, but, since the beginning of hierarchic begins with spin freezing and ends when all clusters will be broken and every cluster becomes in its own independent potential well. Then, one can use matrix order parameter to represent all cases from the beginning of freezing temperature (T_f) until the end of hierarchy.

According to replica theory (SK) (identical copies), taking one cluster, which consists of smaller clusters (M_{i+1}= n), when the hierarchy will begin the children will represent equal small clusters, each one is combined from (M_i =n') clusters. When children clusters have subdivided (parents now), they will represent the smallest clusters. Each one consists of (M_{i-1}) clusters, and so will shape series of ramifications (hierarchies), until we reach the branch of final grandchildren (M_1), which will give then individual clusters and this final situation is the case studied by EA. Thus the number of branches under the condition of replica clusters are given by the following equation:

$$N = \frac{M_{i+1}}{M_i} = \frac{n}{n'} \qquad (9)$$

If the situation M_{i+1} represents an order parameter q_i, and the situation M_i represents an order parameter q_{i-1}, and the state M_{i-1} represents an order parameter q_{i-2}, then the state M_1 represents the order parameter $q_0 = q_{EA}$. For example, in the event of cluster contains four similar clusters (n = 4), we find that the number of branches are equal two branches (replica condition) and the trunk has an order parameter q_1, then followed by the first branch where its an order parameter is q_0 . Fig.2 shows the former description. It can be seen that the total number of the clusters equal to four, and the number of clusters in each branch equals two and therefore the number of branches are two as given by the relationship (9).

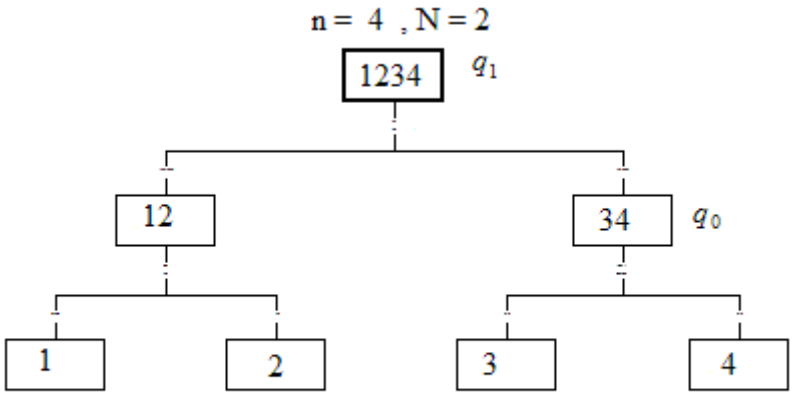

Fig.(2):hierarchical regime

According to the matrix rules, we can write what has already been approved by 4 × 4 square matrix format as:

$$q_{ab} = \begin{pmatrix} q_{11} & q_{12} & q_{13} & q_{14} \\ q_{21} & q_{22} & q_{23} & q_{24} \\ q_{31} & q_{32} & q_{33} & q_{34} \\ q_{41} & q_{42} & q_{43} & q_{44} \end{pmatrix} \qquad (10)$$

In comparison between figure (2) and matrix (10) we find that there is no meeting between the two cases q_{11}. Therefore $q_{11} = 0$. The case q_{12} is existed and represents q_0.the case q_{13} is in the root and its value q_1. The case q_{14} represents q_1..... etc Substituting in

matrix (10) for each elements (as we have early done) we get order parameter as a matrix approved individual cases of the system and find that the matrix order parameter is as follows:

$$q_{ab} = \begin{pmatrix} 0 & q_0 & q_1 & q_1 \\ q_0 & 0 & q_1 & q_1 \\ q_1 & q_1 & 0 & q_0 \\ q_1 & q_1 & q_0 & 0 \end{pmatrix} \qquad (11)$$

This matrix carries all the information that handle the neural network for the transfer of information and figure (2) represents **a model for a mini-brain**; For example, hearing and vision centers of the brain are stationed in four centers (clusters). In the right section there are two and two in the left, each of the two centers connected by two audio and visual nerves with eyes and ears. Thus, two eyes and two ears conveying information to the Centre (brain) according to Fig.(2).

B - Mathematical programs which are applied on hierarchical regime:

There are series of mathematical programs that use the hierarchical regime, the most important programs are (series of spss answer tree , xlminer), (series of statistica)and (series of NeuroSolutions).

By giving data to those programs about the magnetic clusters (the tree trunk or brain), then, these programs can divide those clusters and distribute them according to the hierarchical regime (figure 2). Where the previous operations (divide those clusters) will be applied across some series of operations according to complicated mechanisms, which will be applied on those programs. The program will give us figures represent simple bilateral ramifications or complex ramifications through the giant program (NeuroSolutions).

Conclusions and Recommendations

Spin glass theory can be applied to all system which operate by hierarchical regime such as artificial neural network (ANN) (Internet is huge artificial neural networks), genetic system, the distribution of production, and the stock market.

Theory of spin glass started as a strange unknown regime, and ended by a system that tries to treat the most complex theories in modern era, and try to reach to an artificial brain with super-capacity, Theoretical study indicates that a slide(surface) one centimeter square in area from spin glass alloy would have memories equivalent the storage capacity of one billion megabytes.

In addition to make up a specialist spin glass group , I have been convinced that search need more in search, and more than specialist researcher, especially in, physiology, brain, neural network, genetic…..etc, to make a strong bridge between spin glass system and biological system.

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