EMERGING THE EMERGENCE SOCIOLOGY
The Philosophical Framework of Agent-Based Social Studies

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Abstract

The structuration theory originally provided by Anthony Giddens and the advance improvement of the theory has been trying to solve the dilemma came up in the epistemological aspects of the social sciences and humanity. Social scientists apparently have to choose whether they are too sociological or too psychological. Nonetheless, in the works of the classical sociologist, Emile Durkheim, this thing has been stated long time ago. The usage of some models to construct the bottom-up theories has followed the vast of computational technology. This model is well known as the agent based modeling. This paper is giving a philosophical perspective of the agent-based social sciences, as the sociology to cope the emergent factors coming up in the sociological analysis. The framework is made by using the artificial neural network model to show how the emergent phenomena came from the complex system. Understanding the society has self-organizing (autopoietic) properties, the Kohonen's self-organizing map is used in the paper. By the simulation examples, it can be seen obviously that the emergent phenomena in social system are seen by the sociologist apart from the qualitative framework on the atomistic sociology. In the end of the paper, it is clear that the emergence sociology is needed for sharpening the sociological analysis in the emergence sociology.

Keywords: Sociology, emergence, agent-based, structuration, communication, neural network.

"Human is the ocean,
while every single drop of it is also an ocean"
Muhammad Iqbal

1. Introduction

Probably the most classical question in humanity and social sciences is the quest of where to start the theoretical framework to approach the social phenomena. In generic, sociology learns the human being in their collective behavior, structures, institution, and dynamics: from the collection of human beings to the individual beings. In the other hand, psychology learns human being in their individual structure and how the social phenomena influenced the individuals: from the single individual of human being to the collection of human being. More clearly, some works of the classical sociologist, Emile Durkheim, is presumed to be some kind of dilemma, Durkheim's Dilemma (Sawyer, 2002). Durkheim stated that sociological laws can be only the corollary of the more general laws of psychology; the ultimate explanation of collective life will consist in showing how it emanates from human nature in general (Durkheim, 1895).

Some behaviorists - whether she came from the discourse of sociology or psychology - argue that human being shall only be seen by their behaviors empirically. The behavior is the most important aspects of human being, consequently human being is seen from the mechanism of the their behavior. In practice, human behavior is said to be modified by modifying their operant conditioning (Skinner, 1971). More general approach is to seeing the human being in their sociobiology including the dynamics of evolution, physiology, brain, ethology, et cetera (Boeree, 1997). The most contemporary approach is the effort to the unity of all of the human behavioral sciences, i.e.: economics, anthropology, sociology, behavioral psychology, and political science, in some terms of game-theoretic experiments (Gintis, 2003). This point of view is seen to be the best way of looking at the social phenomena to cope the dilemma explained above.

In the other scientific desk, psychologist is trying to solve some problems of internal cases in the individual human being consciousness that directly or indirectly influencing their behavior, a caveat to the behaviorism approach. Here, the psychologists argue on the existence of psyche where the thought, norms, feeling, and many in-matter objects underlain. Psychoanalysis is probably the biggest school of thought in this concern. However, Sigmund Freud (1930), the father of the psychoanalysis, in the latter work walked through the social picture of the theory of the psyche. He argued that civilization is a human achievement that stands in opposition to human nature psychologically. By this school of thought, the scientists see the social phenomena on cultural aspects of human being in the variable of the intrinsic system hidden in human psychological bedrock. Thus, there is discussion about the origin of human cooperation constructs the social institution and cultural system based upon the way one man's internal situations (Kriegman and Knight, 1988).

The dilemma found in analysis of sociology, actually, came from the emergence conditions discovered (Sawyer, 2002). There is no place of the possibility of the emergence conditions in the classical (and linear) sociology. In other case, we cannot accept the analysis if psychological-based on social phenomena, because the school of thought will be too complicated. It is urgent to have the new sociology to cope the emergence phenomena, to see the social system as a holistic unity and sharpen the scientific explanation on human societies (Situngkir, 2002b).

The term emergence here refers to the macro-level patterns arising in system of interacting agents (Holland, 1998). The pattern cannot be predicted from the usual linear approach, because the system works adaptively in its non-linear dynamics. By this perspective, we will see the social system as a complex system consisting of individuals of human being practiced as agents. The agents interact each other and construct the social system in the macro-level become our focal analysis. By this philosophical point of view, we will do surgery on the complexity of the social phenomena polishing the existing conventional social theories.

This paper proposes the neural network model to understand the complexity of human social. The neural network has been long proved to solve many problems (Jung, Sun, and Mitzuni, 1996) and now we are trying to use this model to emerge the emergence sociology solving the dilemma found by the social theorists. The next section will discuss some theoretical framework of social structures assumed constitute the society based on social system and communication theory and the urgent of the agent based society consistent to the holistic analysis of social theory. The third section will describe how the artificial neural network model becomes the philosophical idea of the agent-based sociology. The fourth will describe the consequences, notes, and some critical points of the emergence sociology in modeling the social structures in self-

organizing feature map of artificial neural network. The fifth will describe the possibility of the further works and research, and the last section will conclude some remarks of the emergence sociology.

2. Theoretical Studies on Social Structures

We begin with the structuration theory stated by Anthony Giddens in (1984, 1993). The structuration theory constructed on the duality of structure exists in generic society. There is macro and micro structure coupled each other henceforth forming the structuration in social life. The structuration is essentially can be seen as the interplay and articulation of those structures which produce us as role-taking and norm-fulfilling beings, and which we reproduce (on purpose or by mistake), as we construct our social reality (Giddens, 1993). The structuration theory is construed by the social structures (i.e.: human action by enabling and constraining) and the human actions (i.e.: social structure by producing and reproducing). Human actions are the elementary unit of the social structures, as they came from the agency of human. By this perspective, structuration theory stated that social life is more than just a random individual acts but it is not merely determined by the social forces (Figure 1).

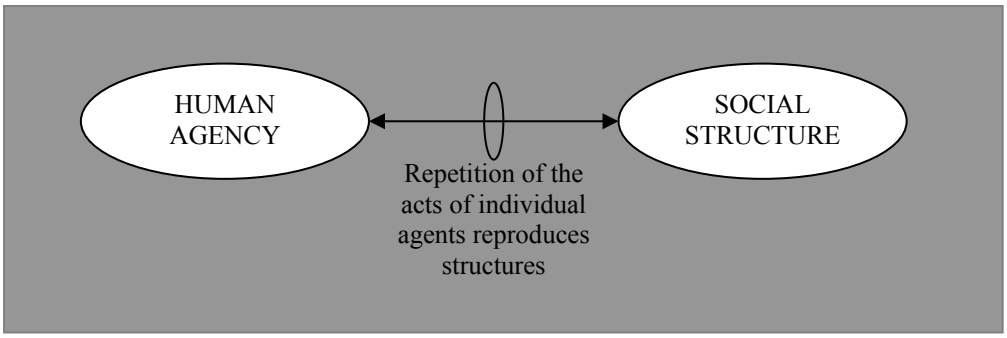


Figure 1
The perspectives of structuration theory regarding two levels of structures of human societies: human agency and social structures

Looking at the interplay of the human agency and the social structure, we can say that structuration theory as constructionist theory which holds that human are social constructs and that their social spaces of all sorts are constructs upheld by humans acting according to their images of what reality is. Social spaces such as institutions, organizations or social networks are constituted by the social rules of interactions. According to Giddens, the rules may be explicitly stated, implicitly learned and the rules become the way to create structures and reduce the amount of uncertainty in the reality.

The social spaces (environment) is created and re-created by the actions of human agents choose to engage in during their involvement in-groups. The rules and contexts in which interactions take place guide the actions but in return the human agents have the ability to monitor and evaluate their actions. The past rules and expectations are used by the agents in making decisions about which actions to engage in. This is called the reflexivity of human agency. Eventually, we can say that there are some basic important concepts in Giddens' structuration theory, namely agency of human, social spaces, and the rule for the interaction within the social spaces. These terminologies eventually can be described as the geometry of the social system dynamics (Klüver, Jürgen and Jörn Schmidt 1999).

To Giddens (1993, p129), meanings, norms and power are three integral elements of action and also of structure. These three elements are what link action and structure. He represents the duality of structure in social interaction in

table 1. In this case, the 'modality' row links the other two, action and structure. For example, communication (the action) comes about when the actor applies an interpretation schema to signification. The three columns express three "integral elements of interaction".

But some problem came up by now since the social system should be seen in the terminology of human agency and the social structure all at once. This is the heart of the complexity in studying the social system. The complexity comes from the interacting human agents that simple in nature and in individual cases but become complex in macro view (Holland, 1998, Kauffman, 1993). The system is moreover has the ability to organize itself (self-organized) in the terms of self-referencing, self-producing, and self-renewing. These characteristics are only be there in the living system and one thing distinguishing the living system with other non-living system (i.e.: physical and chemical system). Humberto Maturana and Fransesco Valera (1988) famously called this characteristic as autopoietic. It is obvious that the structure in this view can be interpreted as the rule of the sociological method.

Table 1
The Structuration Theory

Structure	Signification	Domination	Legitimization
Modality	Interpretative Scheme	Facilities	Norms
Action	Communication	Power	Morality

But how is the method to be operated in the society practically? In this case, Luhman (1990) proposed the "communication" as the particular mode of autopoietic reproduction. By using the beginning words, we can say that the primary element of producing and reproducing the social structures from the human agency is communication. The communication itself will built the network among agents that consistent of the advancement of the semiology as the science about human sign and symbol (Blumer, 2001).

Research for the evolving networks by the perspective of the structuration theory has been done (e.g.: Contractor, Whitberd, Fonti, Hyatt, O'Keefe and Jones, 2000), but the case in this paper to describe is the constitution of the society in sociological perspective of how the emergence to cope with. Henceforth, the epistemological perspectives must be taken is the agent-based social sciences. Sociology in this perspective will be called then as the emergence sociology. Apparently, the elements of this kind of sociology is the human agency, usage of symbol as the primary element of the communications and the actions to be taken in every step of interaction among agents (Leydesdorf, 2002). But the theory describe above is not quite clear to show how the social system internally structured (Fliedner, 2001). The concept of structuration (based on human agency and social structure) is still not connected with the fact of the autopoietic characteristic of the social system and henceforth does not explain the dynamics of the social system and the possibility of the emergence phenomena (Situngkir, 2002a). In advance it is obvious that the using of the artificial neural network models to constructing the agent-based semiotic sociology (wherein to cope with the emergence phenomena in macro-view) will solve the complexity philosophically.

3. Revising Social Structure in Neural Network Model

The vast development of the computational technique has introduced us with the parallel distributed programming that is so much different with the classical one with algorithmic-based. This type of programming has become the basic for the constructing of the artificial neural network. The research of artificial

neural network aims to reveal how the brain processes information thorough neurons. There are three major aspects of artificial neural network model that will be very useful on the revising of social structure theory, i.e.: the weights, the threshold value, and the simple non-linear function on the neuron (Amari, 1993). The weights are the way the neuron chooses information to be processed most, the threshold value is the bias value to the information, and the non-linear function is the way the neuron process the information and deciding the output of the neuron. In fact, the three properties of the neuron are just suited the structuration conditions of human agency (microstructure) described above the 2nd section. This becomes the philosophical framework of the semiotic agent based modeling (Joslyn and Rocha, 2000).

In figure 2, we can see the human agency as a neuron with its internal situation. The environment gives input (signal), and the signal/information is chosen by the human agency based upon her beliefs. This is done by multiplying the signal input to a kind of weight value, the bigger the weight value to be multiplied the more important the signal. The chosen information then compared to the desired or goal states. This is done by comparing with some kind of threshold/bias values, and eventually the sum of all of the signals become input of a non-linear function to output the decision made by the human agent.

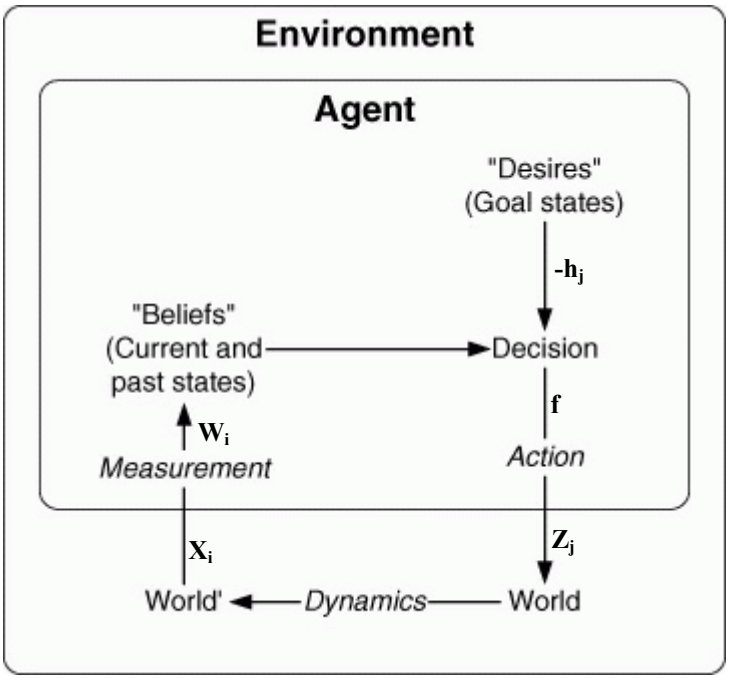


Figure 2

The human agency as a neuron with variables of measurement (weight W_i), desires or goal states (threshold value $-h_j$), and action function as simple non-linear rule (f). In the macro-view, we can see the dynamics of the social structure (environment).

Certainly the action of the agent will give some change in the world/environment and this will become the dynamics of the world. Mathematically, we can say that the human agency is assumed to be a mathematical neuron, receives many (finite) input processed the input and then gives output to the environment (the artificial network).

In the role of social of the duality in structure, the human agency producing and reproducing the social structure, while in return, the social structure enabling and constraining to the human agency. As a mathematical neuron, we can say that the process in the internal environment of the human agency output:

$$z_i = f\left(\sum_{j=1}^{n} w_j x_j - h_i\right) \text{.....(1)}$$

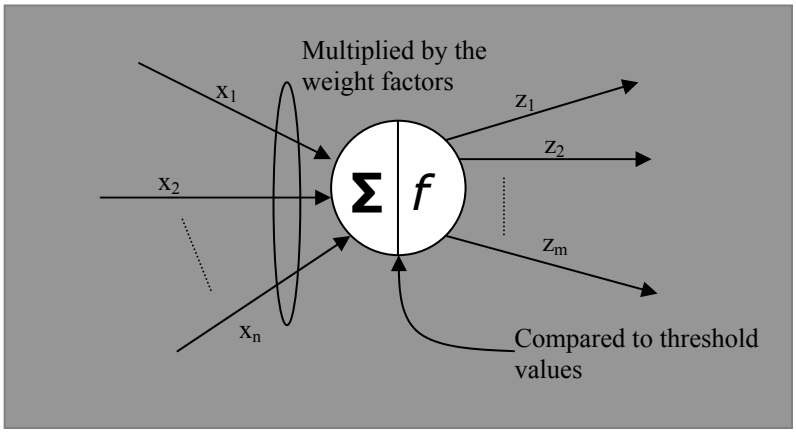


Figure 3
One single human agent as mathematical neuron

The equation means that there will be m number of output (z_i) and can be written by the matrix **Z** with n number input vector **X** with elements noted as x_j. The vector matrix **W** (consisting elements w_j corresponding to the input x_j) and the matrix bias value **h** (with elements h_i, corresponding the output signal z_i). The sum of the weighted input and compared to the bias value will become the input for the simple non-linear function. The non-linear function used in this paper is the usual sigmoid linear as a function that has been usually used in the neural network model.

For example, consider we have a recurrent neural network (fig.4), wherein the output (action) become the input directly, then the dynamics can be stated as,

$$x_j(t+1) = f\left\{\sum_{i=1}^{n} w_{ji} x_i(t) - h_j\right\} \text{..... (2)}$$

We call the vector $\mathbf{x}(t)=(x_1(t), \ldots,x_n(t))$, the state of the network at time t. In this case, the network parameter **W** consists of n^2 weights $w_{ij}(i,j=1,\ldots,n)$ and n threshold/bias value h_i (I=1,…n).

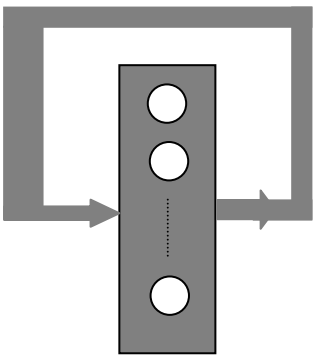


Figure 4
Recurrent Network

We denote the non-linear state transition (2) by,

$$x(t+1) = T_w\mathbf{x}(t) = f(\mathbf{W}\mathbf{x}(t)-\mathbf{h}) \text{ …….. (3)}$$

It is quite difficult to analyze the dynamical behavior of each network specified by **w**, in general. It is usually in the nature of social system, the value of n is large, and we sometimes wish to understand the macroscopic behavior of the networks which have some statistical properties of connection weights and threshold in common, in stead of the detailed behavior of each network separately. Such macroscopic properties are useful for understanding the capabilities of various architectures of neural network model.

By now, we have the individual human action represented as a neuron. It is consistent to the structuration theory, as the value of **W** and **h** can be modified in terms of the modalities of single human action that changed in the dynamical process of learning: signification as interpretative scheme (**W**) and legitimization as norm value (**h**), while the environment supplies the facilities of the whole structure. In the next section we will see how the single neuron constitutes the society as a whole and that usually approached by the classical sociologists by top-down analysis.

4. The Society as Self-Organization (Autopoietic)

One of the most valuable characteristics of the neural network model is its ability to learn. The social system consists of human agents that shall adapt to the environment where she lives. The artificial neuron model that has been described above will be placed now in the system of society with autopoietic properties within. As a matter of fact, there are three ways how a neural network can learn (Dennis, 1997, Gurney, 1997), i.e.: supervised learning with teacher and reinforcement, and unsupervised learning method. It is obvious that the unsupervised learning method is the most suitable learning system of the social system that autopoietic.

We will choose the competitive neural network learning system for this purpose by realizing the every neuron represents the human agency and the social system evolves in the way each agent competing to survive – while the winning agents will be imitated by the losing ones. However, this is an important view of the coupling between the social structure and the human agency. The bounded input and mechanism to produce certain actions can be viewed as a legitimization of the norms or morality.

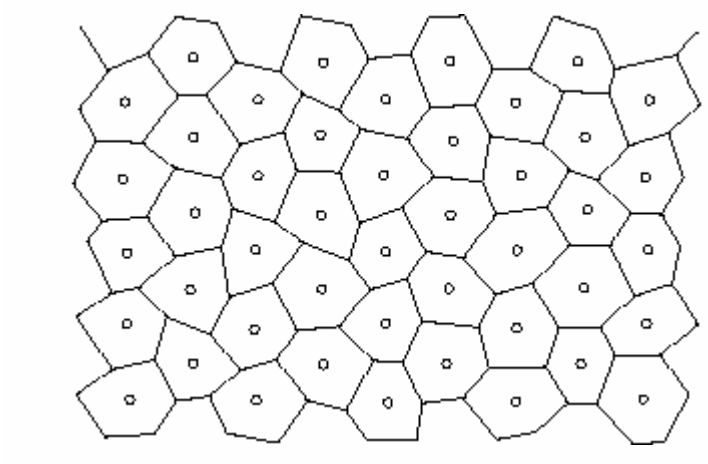


Figure 5
Voronoi Tesselation of a 2-D space

The objective of the competitive learning is to adaptively quantize the input space, which is to perform vector quantization of the input space. It is

assumed that the input data is organized in possibly overlapping clusters. Each weight factor, $\mathbf{w}_j$, should converge to a centroid of a cluster of the input data (Paplinski and Qiu, 2002 ch.9). In short, the input vectors are categorized into m clusters within each weight factor representing the center of a cluster. The vector quantization described here, often called as Voronoi Tesselation. Figure 5 shows the Voronoi tesselation of a 2-D space.

The space is partitioned into polyhedral regions and the center is the weight factors. The boundaries of the regions are planes perpendicularly bisecting lines joining pairs of centers (prototype vectors) of the neighborhood regions. For example, suppose we have 80 input data as normally distributed points for 8 person, and they have to choose with. Each will gain 10 input data. The input data will be categorized in 8 weight values (figure 6). By using competitive learning system, we get the data distributed in 8 weight values. The simulation is made in Matlab™ and by using the function Competitive Neural Network (NEWC) in 1,000 epochs training.

Here, the agents interacts by the value of weight (for the purpose of simplicity we do not set the bias value), and the only we can see is just the effect that emerge from the interactions.

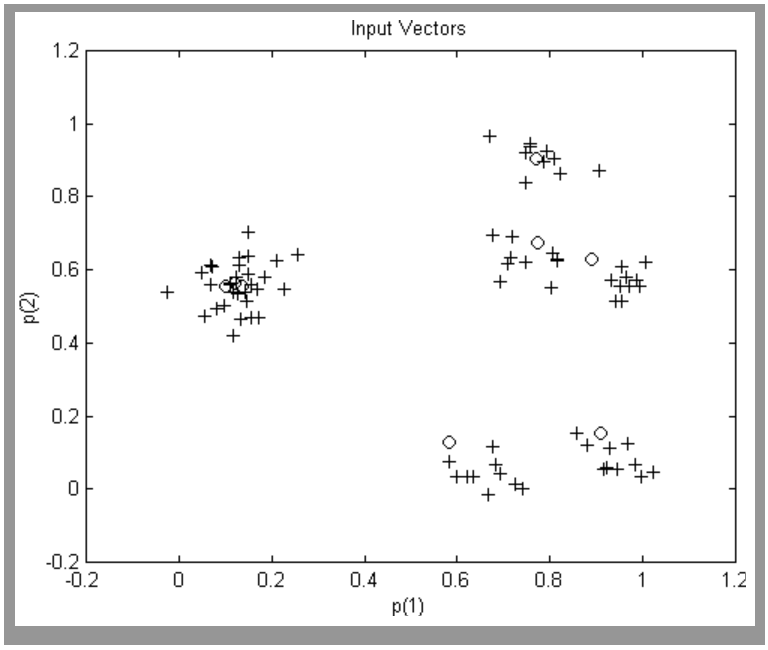


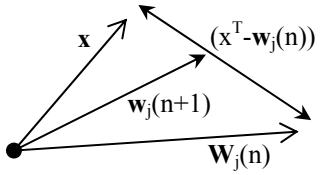
Figure 6
Two examples of the usage of competitive learning system in neural network model.
The input data distributed randomly in the two dimensional spaces ("+"), and the neural network classify the based on the weight value ("o").

Table 2
The weight vector value in the competitive learning neural network

$W_{(1)}$	$W_{(2)}$
0.7717	0.6741
0.0998	0.5565
0.1199	0.5644
0.5813	0.1285
0.8902	0.6280
0.7689	0.9033
0.1378	0.5567
0.9096	0.1528

In the program resulted above, the weight value is set to 0.5, and after the training process, the weight value is as described in table 2. For each input vector we determine the winning neuron, j, for which its weight vector, $\mathbf{w}_j(n)$, is closest to input vector. For this neuron, $y_j(n)=1$. Furthermore, we adjust the weight vector of the winning neuron, $\mathbf{w}_j(n)$ in the direction of the input vector.

$$\Delta\mathbf{w}_j(n) = (n)y_j(n)(\mathbf{x}^T(n)-\mathbf{w}_j(n))$$



We can say now, that the individual agent takes their position in the map and choosing the value of where she should be.

In the next simulation example, we use the more difficult task, where in the agent doesn't not only classify the 800 two element vectors input occurring in a rectangular shaped vector space. The self-organizing map will learn to represent different regions of the input space where input vectors occur. The result of the simulation is in figure 7.

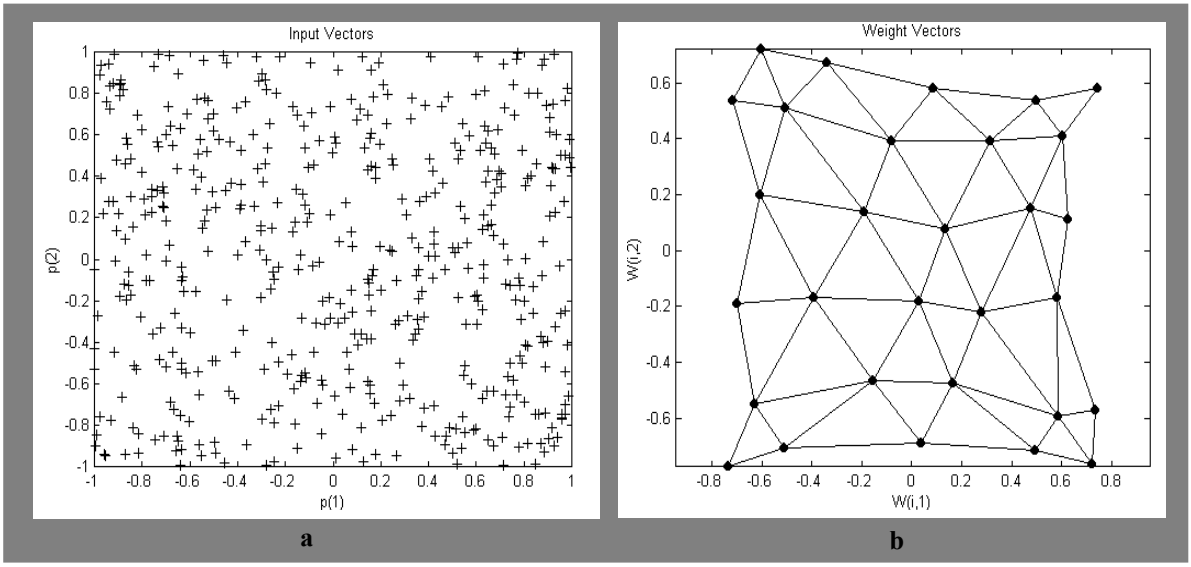


Figure 7

The using of the self-organizing map to classify the randomly spreading input vector (a) in two-dimensional space. The figure (b) showed the result after 1,000 epochs training.

The self-organizing feature map learns to classify input vectors according to how they are grouped in the input space. They differ from the competitive layers in that neighboring agents (neurons) in the self-organizing map learn to recognize neighboring sections on the input space. In other words, the self-organizing maps learn both the distribution (just like the competitive layers) and topology of the input vectors they trained on.

In the last simulation, the self-organizing feature map network identifies a winning neuron using the same procedure as employed by a competitive layer. However, instead of updating only the winning neuron, all neurons within a certain neighborhood of the winning neuron are updated using the Kohonen rule. According to Kohonen (1989), the spatial location of an output neuron in the

topographic map corresponds to a particular domain, or feature of the input data. Thus, the self-organizing maps are competitive neural networks in which neurons are organized in an l-dimensional lattice representing the feature space. The output lattice characterizes a relative position of neurons with regards to its neighbors, that is their topological properties rather than exact geometric locations. Figure 8 showed more clearly about this.

By this understanding, we can say that the individual human agency accept the input vectors to classify. The cognitive mechanism of the agent then occupies some values (weight values) until she can identify how to classify. What we can see from this session of the sociological aspects is only the emerge pattern made by the human agency. Here, the agents (every neuron) learn about her neighborhood and then start to move in order to accomplish the task of classifying the environment spaces. The sociologist cannot see the value of the weight factors or the cognitive process of the human agency, what she can see is only the macro-view pattern that emerge from each agents' actions. The society (in the simulation above) learns to do some sociological pattern, and we can say easily (because we are the programmer) that the society is emerging the pattern of rectangular shaped about the positions.

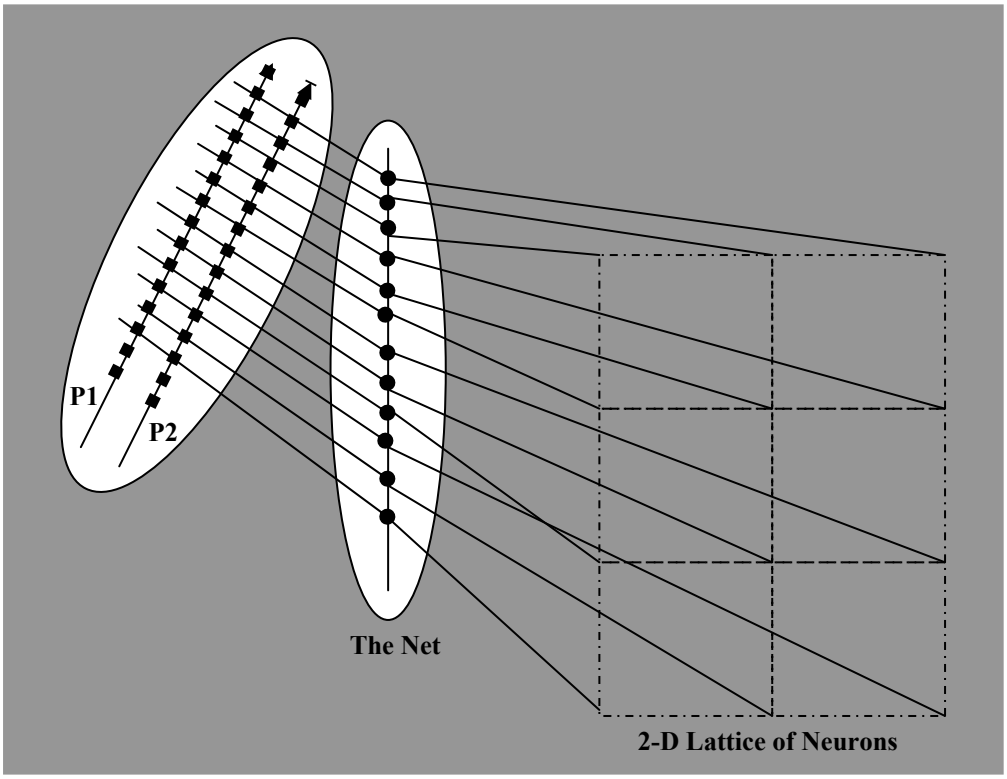


Figure 8

The Self-organizing feature map as describe by Kohonen. The vector input processed by the network and creating the 2 dimensional lattice of neurons. What we can see from the macro-view is the lattice since the processing of P1 and P2 is in the level of the cognitive in each agents.

But the question now is how if we are not the programmers of the society? The answer is by looking at the weight factors that constituting the action of the human agency. By changing the weight factors of the neurons, then we can simulate what kind of macro-view outlook the society emerging. The simulation doing here is very simple, but we can do better in the further research.

All forms of social life are partly constituted by actors' knowledge of them. The sociologist can only have knowledge by analyzing the pattern of the macro-

view. What we said as social knowledge is the accumulation value of all the vector input in the society, and the emergence sociology, construct the analysis from here, and then analyzing person to person by the cultural field where the society laid, and comprehend her analysis with the macro-view empiricism.

5. Further works

The example described above is admitted very simple, since the purpose is to show how the neural network modeling can be used to analyze the social structures as viewed traditionally by the sociologists. However, we can make the better analysis in implementation purpose for social analysis by doing some modification in the model and the use of the fast computer hardware to gain the better experiment result.

Some other improvement that can be made is the usage of fuzzy logic in the value of the weight and the bias vectors (Zeidenberg, 1991), by using the two scalars' similarity given by:

$$e(x,y) = max(min(x,y),min(1-x,1-y)),$$

where x and y are drawn from the interval between 0 and 1 inclusive. In this case, x and y become the variables that represent the degree of truth of two propositions, and e represents the degree to which they are equivalent. Nonetheless, in the artificial intelligence engineering this has been such usual sort of thing.

The other further possible work is the analysis of using the various non-linear functions in modeling the artificial neuron, and show what causal aspects can be gained by using the different non-linear function.

6. Concluding Remarks

The usage of self-organizing artificial neural network model for describing the role of the social structure has been revisited. This will become the philosophical framework for the more bottom-up analysis rather than the traditional sociologists do in the top-down macro-view that has been give up on the atomistic sociology. In the early times of the birth of the sociology as a science, Durkheim has been stated this to become the dilemma of the social sciences. However, the psychology has given us much explanation that sometimes too sociological if it cannot be said a fatal.

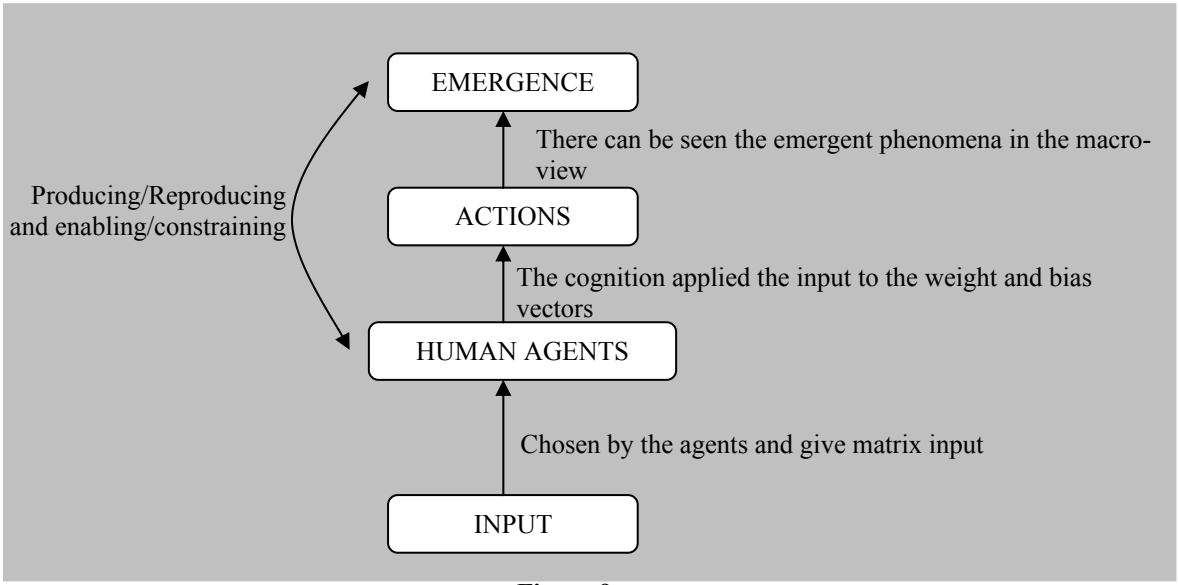


Figure 9

The way emergence sociology views the social structure. In the various neuron model, we can get the multi-agent model of society.

In the neural network model, the neuron makes its decision by using the weight and the bias factors that suitable cognitively with the real way we are making any decision, whether it is rational or irrational. The agent-based model has given many things to do with this for the more bottom-up analysis and approach. By the example shown above, we can see that neural network model in the environment of self-organizing has given us some perspectives, on how traditional sociologist working out and make their propositions. To concluding the paper, figure 9 show the autopoietic social system behaves as analyzed bottom-up.

The society is learning, just like the neuron learns how to set up its weight and bias vector. And the macro-view of the neural network model emerges any patterns that cannot be predicted looking at the value of the weight and the bias vector *an sich*. The vast computational technology to day, has given us possibility to establish the sociology to cope any sociological emergence phenomena, the emergence sociology. It is all depend upon our competency to use it for the further and advanced innovations.

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