

The evolution of complex information systems as movement against the pull of entropy, measured along information-space-time dimensions.

Arie S. Issar

Professor Emeritus Ben Gurion University of the Negev
84990 Israel
e-mail: issar@bgumail.bgu.ac.il

"If we're ever going to find an element of nature that explains space and time, we surely have to find something that is deeper than space and time - something that itself has no localization in space and time." (John A. Wheeler in Davies and Brown, 1986, p. 66)

Abstract:

A new basic dimension is hereby introduced in order to explain the emergence as well as the evolution of ordered complexity in the bio-world. It is suggested to be defined as "the dimension of information", which relates to all what is measured by a computer. (While space is all what is measured by the meter and time is all what is measured by a clock). It has four degrees of freedom namely addition and reduction (i.e. '+' & '-') and induction and deduction (I.e. 'if-then' and 'when-then'). The living cell can be thus described as a system on space-time-information dimensions, able to transform sequences of events from the coordinates of space-time to that of information. This is accomplished by the transformation of mechanical and electro-chemical stimuli into ordered complex structures of notions (which are equivalent to points on the dimension of space, and to instants on the dimension of time). The rise in complexity of the structures of notions on the dimension of information enables the promotion of concepts into ideas and into theories. In order to do this energy has to be invested. This is because it is a movement opposing the slope of universal entropy. In other words, the universal pull towards infinite disorder=entropy, is described as the geometry of space-time-information continuum, which has eleven degrees of freedom (spatial x,y,z, each of which has two degrees of freedom, temporal, which has one degree of freedom from past to future and information with four degrees).

A. Introduction

The conceptual model, herewith presented, evolved in connection with the author's involvement in the research of the geology of the Quaternary. In this research the recent evolution of the mammalian fauna as well as that of man, as revealed by pre-historical artifacts were basic tools for building a spatial-temporal i.e. stratigraphical-geological model.

The philosophical question, which cropped up during this research, was whether there exists one general theory, which may explain the evolution of the form of the fossils found in the layers and the evolution of their intelligence, which in the case of man is expressed by his capacity to produce more and more sophisticated tools. A partial answer to this question was found in results of the research by Bitterman (1965), who, after many

experiments, found out that the evolution of intelligent behavior is correlative with the place of the species on the evolutionary scale. In other words ascent in the level of intelligence was parallel to the appearance of these forms of life on the geological timetable. This meant that the place of the species on the tree of life could be measured also according to the level of its intelligence. Bitterman (op. cit) also defined the difference between instinct and intelligence as *"the ability to develop a new way of reaction when an entirely new situation comes up"*.

The question then came up, but what is intelligence? Can one measure it on the same set of coordinates, i.e. space-time, on which the evolution of the form of the fossils and artifacts is measured? At this stage the author came upon an article by Brain (1968), who as a result of his research on the mind came to the following conclusion:

"To end with a speculation, I suspect that our difficulties arise in part, at least, from our analysis of events into a four dimensional space-time. We can describe events in this way, indeed we are compelled to do so by our own biological organization, but I fancy that there are living events, which we will fail to understand until we can describe them also in terms, which may involve additional coordinates. Then we may transcend both the old materialism and the old mechanis."

These words, coming from an expert in the field of the works of the brain and mind, gave the present author the idea to look for a new dimension.

This brought up a new question: how can a basic dimension be identified and then defined. A research into the history of the theory of the dimensions of space and time, taught the author that when it comes to the basic dimensions of space and time, one couldn't prove their existence, only by using their own attributes. Thus the only way to prove their existence is *de facto*, namely while measuring the space-time events. This brought up the premonition that may be that intelligence itself is a dimension. Exploring this direction of thought, the author, by a process of generalization came to the conclusion that the phenomenon of intelligence is a special case on a more general dimension, which is that of information (Issar 1980,1982,1984,1995).

When the author published this hypothesis, it was met by an opposition, which the author suspected has to do with man's subjective image of himself, namely that there might exist a mental barrier, which prevents man from viewing the act of thought in an objective way. This subjectivity is attributed to the anthropocentric heritage, (remnant from a more primitive stage on the ladder of evolution) which equates observation, thought, (i.e. the acquiring and processing of information) and the existence of the observer and thinker. One says "I think", "I understand" which makes it difficult for him to grasp thinking as something independent of the thinker's self, like movement along a dimension. This difficulty is similar to that which people from certain tribes in Africa face in grasping time as something separate from an act they perform, thus the hours of the day are according to deeds accomplished (Mbiti 1969). Bedouin people, as the author of the present paper found while working with them, have a difficulty to divide space from an act performed while moving. Thus when asked what is the distance to a certain place they will answer the number of cigarettes one smokes until he reaches the place, or time it takes a man, or a camel or a car to reach it.

In the following chapter an essay will be made to convince the reader that when he thinks intelligently he progresses on the dimension of information, an act similar to that of moving along the dimension of space.

B. Information as a new dimension.

Let us ask what is the difference between an egg, just fertilized, in the wombs of a woman, a monkey female, and a hen? They all look the same on space coordinates. Biologists will tell us that they differ by their genetic code. To the question what makes the difference? They will answer the character, number and geometrical arrangement of the chemical bonds in their genetic code. All these differences put together they will call information. A scientist investigating the genetic code of a certain genus is assumed to have a mental picture of this code in his mind, as well as on his computer's memory. Once he has published his findings, this code is presented in symbols of letters and digits. His fellow biochemists after reading his paper have an image of it in their mind. Now let us imagine that the genus become extinct, we will still have the information about the genetic code of the extinct genus. Using Popper's terminology, we will say that the genus still exists in the '*the third world*' (Popper 1972). Let us assume that the same catastrophic extinction happened to a certain species of microbes, fish, and primates. We then ask the question what are the differences in between them from the point of view of the information stored. One of the answers may be the quantity of memory needed on the computer's hard disk. Once the concept 'quantity' is stated one has to agree that there exists an act of measurement on a certain dimension. The question is whether it is a basic new dimension?

To answer this question let us assume that we have samples of a few stages of growth of the extinct creatures. The differences between egg, baby and adult, are undoubtedly measurable along the dimension of time, and along the dimension of space, which is expressed in the changes in size and form of the bodies involved i.e. from one microbe to two, from yolk to bird, from embryo to baby. Such a change can be described on a space-time coordinate system. Yet the changes in space-time were directed by a code, which although existed in the space-time event of the primary stage, it dictated the potential evolution of future space-time events. Thus if one agrees that the changes are a function of time and space, and of the information in the genetic code, why should he not call this which defines the future arrangement on space-time coordinates as another dimension? In other words any living individual at any moment is a space-time-information event.

To help get the hang of information as a dimension, let us elaborate on the question what makes a hen wiser than a chicken, or a grown up man wiser than the baby just born? The answer most probably will be that that the grown up individual has more experience, namely it acquired more information from the environment, processed it and acquired a data base, which is built on the principle of: 'if-then'. Another aspect of this dimension is revealed when one asks the question: what does a certain scientist mean when he says "I am more informed" after he has read the article about the genetic code of the extinct creature, and what is the meaning of the value showing the number of bits he has used after he has summed up the new knowledge on his computer? In all these cases he relates to an additional quantitative entity, which differs a certain system (either himself or a computer, or another creature) from the state in which it was before the information was acquired. It is argued that this is a dimensional entity, like space and time. Thus instead

of saying the creature has grown up during the period of the observation and acquired more information, one has to say: It grew up along space-time-information dimensions, (The same as did its observer).

When it comes to the definition of the dimension of information, the dimension of information does not differ from space and time, due to the reason that a basic dimension can only be defined by itself. Thus in order to avoid the philosophical catch of arguments which classical philosophers got entangled with, when trying to define space and time, the operational definition has to be adopted. Thus space is defined as: 'all what is measured by a foot or ruler' and time is defined as: 'all what is defined by a pulse or a clock'. The dimension of information is suggested to be defined as; 'all what is measured by a brain or a computer'. When it comes to the degrees of freedom of movement along the various dimensions, space will be referred to as: a dimension with six degrees of freedom (x-y-z forwards and backwards). Time as that with one degree of freedom, namely from the past (through the present, which is the finite smallest portion of time i.e. instant) to future (t1-t2-t3) the dimension of information has four degrees of freedom namely addition and subtraction (i.e. $1+1+1=3$ and $3-1-1=1$) and induction and deduction (i.e. 'if- then' and vice versa). (recalling past events namely the reverse movement on the time dimension is possible only after the transformation of the space-time event to an image on the dimension of information) .

Once information is regarded as a dimension, it is suggested to elaborate on its characteristics, in correlation with space-time. The smallest finite entity, without direction, on space and time are point and instant. Their equivalent on the dimension of information is a notion (or a bit on a computer). A concept (coded as a word) is a few notions put together equivalent and reflecting a certain event on space-time. The different arrangements of a few notions (or bits) make a different concept or word. The different arrangements of a few concepts make a different idea or sentence. All these are information-events, or images which reflect space time events, whether outside or inside the body of the observer.

The dimension of information is intrinsic in the space-time-information continuum, which answers the dilemma: why natural laws conform to theoretical mathematical laws, expressed by the question "*Is the creator a mathematician?*" it renders enumeration to the other dimensions. In other words it makes points and instants countable, and enables to define orderliness in space-time-information events.

Ordered information i.e. intelligence, is defined as information arranged according to information, namely, as constructs on the dimension of information according to mathematical-logical laws. These are composed sets of notions-bits structured by inductions and deductions built on inductions and deductions. Thus, ordered-complexity is increased by the combination of structures (of notions, concepts, sentences, ideas, theories etc.) along the dimension of information according to mathematical-logical steps. When these laws are not obeyed the world-view is distorted.

We call events theoretical or conceptual when we refer only to their structure along the dimension of information (i.e. their measures on space dimension and time dimensions are very small that they can be neglected). Reality is structures composed of ordered sets of quanta of point-instant-notions, built along space-time-information dimensions. Truism is tested by the conformity of the structure built along the dimension of information with reality namely 'space-time'.

The size of an information-event i.e. idea, (equivalent to a body on the space dimension, and duration on time dimension) is measured by the number of steps taken along the dimension of information. The level of ordered-complexity, or organization of a theory, is a function of the number of logical steps (i.e. acts of addition of notions and their organization into sentences, ideas, etc.) combined to build the more general theory. The more elegant theory is the one more economical in the number steps and thus in the number of notions or bits of information which were used to reach the same goal (i.e. the straight line between the starting concept and the last conclusion).

It is suggested to adopt a practical unit of measurement of consciousness, which will be: the quantity of energy, which has to be invested by an ideal Turing machine to construct a unit logical sentence.

A computer program, as well as its software can be described as a map on the dimension of information. The increase in the complexity of the programs is by adding degrees of freedom equivalent to that of adding "dimensions" to a space-time map. The difference between the artificial intelligence of a computer and natural intelligence or consciousness of the bio-world, is that artificial intelligence is confined to the degrees of freedom to which it was programmed by an intelligent conscious programmer. It can thus explore areas on the programmed map but not to multiply its complexity. The brain on the other hand has the capability to "increase" the degrees of freedom of the mental structures, by multiplying the basic degrees of freedom and thus arriving at higher levels of ordered-complexity. Evolution of intelligence in the bio-world i.e. from the first living organism to homo sapiens and beyond, (which is inter-related with the evolution of form i.e. space-time) can be described as ascending the ladder of ordered-complexity of the maps along information dimension. The level of intelligence of the individual is defined as the faculty to produce (and act upon) a program on a higher level of order than that imprinted as a instinct. Instinctive behavior is the faculty to act only according to the program imprinted in the DNA or brain of the individual or genus.

C Universal entropy (including the bio-world) as curvature of space-time-information geometry.

It is suggested to investigate the example suggested by Denbigh (1989) of a "fertile bird's egg inside an incubator" in the framework of the conceptual model herewith presented. "The latter contains a sufficiency of air and was initially raised to a temperature high enough for the hatching of the egg. The incubator was thereafter surrounded by perfect thermal insulation with the consequence that its total entropy can only increase or remain constant". If the egg dies "there is an entropy increase accompanied by the process of disorganization". The question, brought up by the present author, is: Why should entropy increase and why should there be a process of disorganization? To show that this question is legitimate, from the scientific point of view, one can ask also, why is the egg not floating in the mid air of the incubator. The answer, of course, will be that it is known that the incubator, as well as the egg in it, are influenced by the space-time curvature formed by the mass of the earth. Moreover, if the egg is placed on a shelf in the incubator and it falls and breaks down, the probability that it will assemble itself and float back to its place on the shelf approaches zero. When it comes to the fall of the egg no physicist will argue against connecting its fall with the

geometry of space-time! Yet when it comes to its disintegration no suggestion has been raised, up to date, to look for some kind of geometry of the universe, which may decide the increase of entropy. The working hypothesis suggested in the present conceptual model is that of a universal geometry of space-time-information and which has 11 degrees of freedom, which acts perpetually to increase the entropy of the incubator on the whole, and the disorganization of the egg in particular, including the information code imprinted in it. The investment of electrical energy, transformed into heat, in the case of the egg, helps to stand up and even move against the pull of the field of entropy. In more general terms, it is hereby suggested to perform a mental exercise, similar to that which Newton might have performed when he was looking on the apple tree. This exercise requires us to look for a force outside the egg, as the reason for its fall from its present level of organization and the increase of its entropy. The same trend of thought will bring us to correlate between the need to invest energy in order to keep, or increase, the order of a living system, to the energy, which one has to invest in order to act against the pull of gravity.

Physicists, will undoubtedly oppose the giving of a geometrical expression to entropy claiming that the universal field of entropy is curvature of space-time-information as it implies that the pull towards entropy is due to a field of force, in correlation with the field of gravity, which can be described as curvature of space-time. The physicists will argue that by definition a field of force have to be reversible in time, namely every movement can be reversed to get back to the initial point, and the movement, forward and backward, can be precisely measured. While thermodynamic systems are by definition irreversible in time, this is connected with the conjecture of the 'arrow of time', which is intrinsic in the theory of thermo-dynamics. In other words according to the second law of thermodynamics (SLT), there is a perpetual loss of order in the universe, and thus each moment, on the dimension of time, differs from its neighbors. Moreover thermo-dynamical phenomena are statistical by nature, while field equations are deterministic.

The main answer to these arguments is the question whether it is not possible that the differences between the conditions in a conventional physical field and the universal field of entropy lie in the number and degrees of freedom of the dimensions, along which each field is measured? Conventional fields, and as a matter of fact non-quantum physics, are restricted, by definition, to space-time measurements, and do not take the observer, which is the information-meter into consideration. It is claimed that once the observer, and his world-view, are introduced into physics, reversibility and precision disappear as shown by quantum physics. The argument, that this will not comply with the universal SLT as expressed by Clausius, i.e. perpetual increase in the entropy of the universe, is answered by the counter argument that Clausius' formulation is restricted to space-time. While universal entropy should be measured in space-time-information. This takes also into consideration the ordered information, imprinted in the bio-world since the first environment-responsive molecule i.e. conscious organism, came into existence. As an illustration one can ask the question, how to calculate the energy balance of the system called: Clausius arriving at the SLT, or Einstein arriving at $E=MC^2$.

Going back to the geometrical description of a field, it is suggested now to construct a coordinate system representing space, time and information on which the degrees of freedom of movement are dictated by the character of the dimension, and all together

eleven degrees of freedom (i.e. "dimensions" in the conventional terminology). Each intersection of coordinates is a point-instant-bit entity, which can be described as the smallest finite observation quantum. Maximum entropy is the state in which this coordinate system is homogeneous and isotropic (maximum symmetry). Any disturbance in the symmetry is an event, which can be described in relation to any set of coordinates. Thus a thermo-dynamic event, strictly speaking, (to which Denbigh op.cit. refers), is a process measured in relation to space-time coordinates only. This will be for example the temperature of the incubator and the egg. The DNA code of the egg is a space-information event. On the other hand change in the 'structural-organization' of the egg will be described in relation to information-space-time coordinates. The theory, describing this evolution is an event related to the coordinate of information solely. Its evolution, which is the increase in its ordered complexity, will be described as increase in the level of the derivative (information as a function of information). The theory put in writing is an event described along space-information dimensions, while for the description of the historical evolution of a theory one adds the dimension of time.

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