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Time, Space, Information and life

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One of the most intriguing aspects of life must be the concept of time! In other words, if there is no time, then there would be no life! Life may be known as; if there is a beginning, then there is an end! In a broader sense; life can be repeated again and again until it is totally disappeared, such as human race. But each human life is actually a different life!

1 Time and Space

One of the most intriguing questions in our life must be the existent of time. So far we know that time comes from nowhere and it can only move forward but cannot move backward! Although time can slow down somewhat, from Einstein's theory of relativity, but so far it still cannot move backward or even stand still!

Then there is a question, if time does not exist then how can we know there is a physical space? Thus, there must have a profound connection between time and space. In other words, if there is no time, then there would be no space!

A physical space; I would call it a Temporal Space, as in contrast with a Virtual Space. In other words, Temporal Space is a space that is described by time, while virtual Space is an imaginary space without the constraint of time.

Let us now take one of the simplest connections between space and time, as given by;

$$\mathbf{d = vt},$$

where d is the distance, v is the velocity and t is the time variable. We note that, this equation may be the most unique representation in connecting time and space!

Needless to say that for a three-dimensional (Euclidean) physical space, it can be described by;

$$(dx, dy, dz) = (vx, vy, vz)t,$$

where (vx, vy, vz) are the velocities vectors and t is the time variable.

It is interesting to note that by replacing the velocity vectors equal to the speed of light c, the physical space can be written by,

$$(dx, dy, dz) = (ct, ct, ct).$$

In view of this relationship, we see that time can be traded for space! While space may not be traded for time, since time is a forwarded variable!

For example, a television panel is a typical example of trading time for space, in which a TV picture of (dx, dy) can be displayed by a given amount of time t.

Again, we note that, t is a forward moving variable, and it cannot be traded at the expense of space (dx, dy)! In other words, it is the time that determines the physical space and it is not the physical space that can bring back the time that had been expensed! Nonetheless it is the size of space that determined the amount of time required to describe it!

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The major differences between Reality & Virtual-Reality are that: In reality (i.e., real world), time may be relatively slow down somewhat as the velocity approaches the speed of light! While in Virtual-Reality space and time can be simply traded!

2 Time-Space, Energy and Mass

Let us look at the space and time equations again, as given by;

$d = vt$ or $d = ct$,

In view of these energy equations;

$E = 1/2(mv^2)$ or $E \approx mc^2$

we see that either **v** or **c** is related to $\mathbf{(E/m)^{1/2}}$, which can be written respectively, as

$v = (2E/m)^{1/2}$ or $c \approx (E/m)^{1/2}$

in which the velocity of light is assumed a constant. Thus we see that, there existed a profound relationship between velocity and energy and mass. Without these relationships, it is not possible to connect the time and space!

Thus one may see that, without the existence of time, there would be no space! And without the space, how can we define mass and energy? In other words, without the existence of time, then there would be no space, no mass and no energy! And the universe we known would be absolutely empty!

There is however a physical constraint imposed on time-response in space. In any physical system, the output response cannot be responded ahead of the input excitation and there is always a time delay. We know that a system responses instantly with time if and only if the system is a memory-less system. Since electro-magnetic wave (e.g., light) travels at speed of light, it is apparent that the universe we know cannot be actually memory-less (i.e., actually empty). Then if the universe is not actually empty, it must fill with substances, which is still beyond the current technology can detect! Thus we see that the time-space concept may not just limited by the velocity of light!

Nevertheless**, o**ne question remains to be asked, is our universe imbedded in an empty space? Since by definition, the emptiness implies no substance, no time, no coordinate, not even bounded or unbounded. It is therefore impossible for our universe to be imbedded in an empty space! Then if the universe is not imbedded in an empty space, then it must be imbedded in a more complex space. Yet this complex space has to be found! Thus the time and space concept, in which the universe is imbedded, would be more intriguing, profound, and esoteric!

3 Time, Space and Information

For example a vocal voice is a temporal signal or temporal information and a picture is an example of spatial signal or spatial information. Notice that these are the two types of information can actually be interfaced or interweaved for transmission! For instances; TV display is a typical example of exploiting the temporal–information transmission for spatial-information display, old-fashion movie sound track is an example of exploiting the spatial-information for temporal-information transmission and a continuous running TV program is an example for spatial and temporal information-transmission.

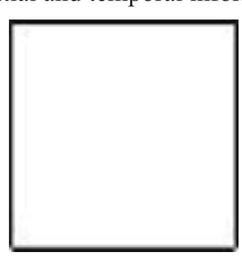

Fig 1. A two-dimensional spatial space.

Let us now look at the Information content of a spatial-space. The Space-Time relationship that we have described is not empty! Even from the virtual space stand point, the space should fill with substances; otherwise it would be a null space!

For simplicity, let us assume a single-cell two-dimensional (2D) spatial-space as shown in Fig 1.

Notice that every physical-space requires time to describe it. If we assume the spatial-space is represented by a binary cell either black or white (i.e., 0, 1), at a given time t, then the spatial information content of this single-cell spatial-space can be shown as [1,2],

$I = \log_2 2 = 1$ bit

in which we assumed the probability of providing either 0 or 1 spatial-space is equal-probable.

Let me emphasize that, every bit of information requires a duration of time Δt to transmit, to process, to store, to retrieve, and to learn. In other words, every bit of information has a price tag or price tags; namely in time, in energy and in entropy, as will be discussed later and it is not free!

Similarly if we extended the spatial-space to a two-cell space, and again using binary representation for our example, as shown in Fig 2 below, in which we see that the spatial-information content provided by

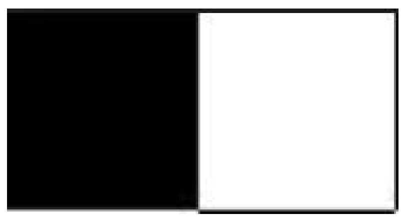

Fig 2. A two-cell spatial space.

this two-cell spatial-space would be;

$I = 2(\log_2 2) = 2$ bits.

Similarly for an N-cell spatial-space (shown in Fig 3) we would have,

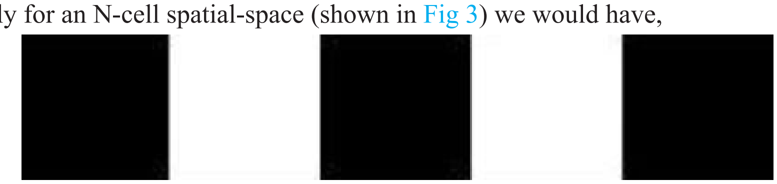

Fig 3. An N -cell spatial space

$I = N(\log_2 2) = N$ bits.

Needles to say that, for a 2-dimensional N×M-cell spatial-space (Fig 4), we have,

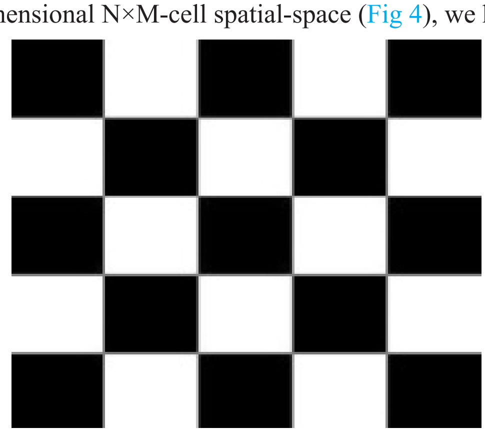

Fig 4. An N × M-cell spatial space

$I = (N\times M)(\log_2 2) = N\times M$ bits.

If each cell represents one of 8-distinguishable gray-level, then the spatial-information content can be shown as,

$I = (N\times M)(\log_2 8) = (N\times M)\times 3$ bits.

Similarly for a 3D (N×M×H) Cubic spatial-cell (Fig 5) as shown below,

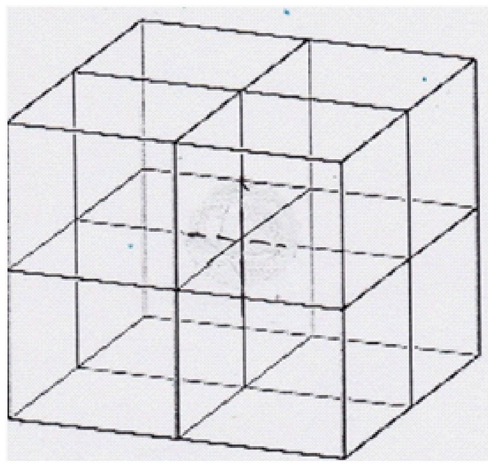

Fig 5. A three-dimensional cubic-cell spatial space.

The spatial-information content can be written as.

$I = (N\times M\times H)(\log_2 8) = (N\times M\times H)\times 3$ bits.

Thus we see that the amount of spatial-information provided for a W distinguishable gray-level 3D cubic spatial-cell would be,

$I = (N\times M\times H)(\log_2 W)$ bits,

This is in fact the minimum amount of spatial-information required to create a 3D cubic cell with a W distinguishable gray-level, under the assumption of 100% certainty!

4 Entropy and Information

Let us look at the Boltzmann's entropy equation as given by [3],

$S = k\, ln N$

where k is the Boltzmann's constant, *ln* is the natural log and N is the total number of the possible distinguishable stages.

In view of the preceding equation, we see that there exists a profound relationship between the entropy and information, for which we show that [4],

$S = kI\, ln(2)$ or $I = S\,[1/k\, ln(2)]$

Thus we see that, each quantity of information can be represented by an amount of entropy. Notice that besides the time and energy required for transmission, processing, storage, retrieval and learning, we need to pay in terms of entropy to generate the information.

Since entropy is defined as [3,4]

$S = \Delta Q/T$,

where ΔQ is an amount of heat received and T is the absolute temperature in Kelvins. Thus we see that entropy is also associated with an amount of heat or energy!

5 Minimum cost to create

For example, the cost of entropy required (under the equal-probable condition) to create a 3D (N×M×H) cubic cell with a W distinguishable-level, we need the amount of spatial-information;

$I = (N\times M\times H)(\log_2 W)$ bites,

or equivalently the amount of entropy required, that is,

$S = \{(N\times M\times H)(\log_2 W)\, k\,ln2\}$.

We note that, this is the minimum cost of entropy required to provide this spatial-information.

Thus we see that, the price paid for the entropy is a necessary condition and the time and energy paid (for processing, for transmission and others) is the sufficient condition to make it happen. Again we see that every bit of information has a price tag or price tags, namely; entropy, time and energy.

We have shown that the amount of information provided and the cost of entropy required, then what would be the minimum cost of energy to create a spatial-space having a mass of m?

Let us take the Einstein's total energy equation as written by [5],

$E \approx mc^2$,

where m is the mass, **c** is the velocity of light. Thus we see that this must be the minimum cost of energy required if one wishes to reverse it.

Let us now assume one would like to create a 3D cubic cell as described in the earlier illustration and further assume it has a total mass of m. Therefore, for one to create this cubic cell, he/her requires a minimum cost of entropy that is [5],

$S = kI\,ln(2)$,

where $I = (N\times M\times H)\log_2 W$ is the amount of spatial-information required. And the minimum cost of energy required for him/her to create is given by,

$E \geq mc^2$

Thus we see that, a huge amount of energy is needed! We note that this is the necessary condition but not sufficient, to create the cubic spatial-space. For example, the creator needs also the amount of entropy (or equivalently the amount of spatial-information) for him/her to make it happen!

A question remains to be ask, **w**hat would be the required amount of information to create a binary 8 spatial-space? Since it has $2^8 = 256$ possibilities, the minimum amount of spatial-Information required = 8 bits. We see that if each spatial-space is attached with a gram of mass, then the minimum energy required to create this binary 8 spatial-space would be,

$E \approx 8 \times (\text{gram}) \times c^2$,

where **c** is the speed of light. Notice that this amount energy required is about 8 times the energy released by the atomic bomb dropped at Nagasaki at the end of World War II!

Again, this is the minimum energy required under the assumption that the creator can reverse the Einstein's total energy equation. Even we assume the creator can reverse energy to mass, but the creator still needs the 8 bits of spatial-information (or equivalent entropy) to make it happen!

6 Essence bit of information

Let me emphasize again, every bit of information has a price tag or price tags! For example, every bit is associated with an amount of entropy and it takes time to transmit, to process, to store, to retrieve, and to learn! In fact every bit of information is limited by the Uncertainty Principle [6,7], i.e.,

$\mathbf{\Delta t\, \Delta \nu \geq 1}$, in which time resolution **Δt** is an expendable quantity! **Δν i**s the frequency resolution. Thus we see that every bit of information indeed requires an amount of time **Δt** to transmit, to process, to store, to retrieve, and to learn! Notice that the relation can also be written in terms of energy and time variables as given by;

$$\Delta t \, \Delta E \geq h,$$

where **h** is the Plank's constant. This is the well known Heisenberg's Uncertainty Principle [8,9]. In view of this equation we see that every bit of information is also required an amount of energy ΔE for transmission, processing, storing, retrieving, learning and assembling! Once again we see that, every bit of information is not free and there is always a price or prices to pay! The question is that, can we afford to pay for it?

Let us now assume a mechanical clock and its mechanical parts shown below (Fig 6):

Fig 6. Mechanical clock and its mechanical parts

If we provide a layman with all the parts that he/she needs to assemble this mechanical clock and the question is that, how long would it takes for him/her to assemble it? I think it will take him/her a long time (e.g., may be days) to assemble the clock.

On the other hand, if it is assembled by a clock-smith, how long it will takes to assemble it? Certainly it will be much, much shorter for him/her to do it, since he/she has a priori information (i.e., knowledge) of assembling a clock.

My next question is that, If we provide the layman all the materials to build the parts, how long it would take him/her to actually build a clock? My answer to this question is that, it may take years for him/her to actually build a clock since the layman has never seen a clock before and added he/she may not know how a clock works or even existed!

In addition, for the clock maker to actually create a clock from nowhere (besides the amount of information required) he/she needs a minimum amount the energy to make it happen as given by,

$$E \geq mc^2,$$

where **m** is the total mass of the clock, in which we assume that the he/she can reverse the Einstein's total energy into mass! We further note that besides the information content required to assemble the clock, the he/she also needs additional information to produce the correct materials (e.g., metals, springs, etc.) during the course of reversing the energy into mass. And this additional amount of information (or entropy) required is even greater!

For example, if we assume the mass of the clock is about one kg**,** then the minimum energy required would be equivalently equaled to 1000 times the energy released by the atomic bomb dropped on Nagasaki at the end of World War II! Again, aside the huge energy required, he/she needs the cost of entropy (i.e., equivalent amount of information) for producing the right materials to make the clock and also needs the cost of entropy to assembling them into a clock! Thus we see that the overall cost of entropy (or amount of information) needed is extremely large!

One may further ask, how long it would take us actually to develop a mechanical clock, similar to the one shown in Fig 6? The answer is that, it took decades for us to develop one!

One of the interesting questions may be ask, what would be the cost of energy and entropy to create an adult chimpanzee on this planet earth? And the next question is that, what would be the chance for the created chimpanzee to survive without the basic living skills (i.e., information or entropy) in this hostile planet earth?

7 Final Remarks

In view of the preceding discussion, we see that time is the most intriguing concept in our physical world, so far we seem to know a little about it, yet it is still remaining as one of the most intriguing and fascinating aspect in life!

Time can only advances and cannot move backward or even standstill? It is the existence of time, where the concept of space existed. Without the aspect of time, how can we define the (physical) space? Without time and space relationship, then there won't be the existence of mass and energy, the universe and us! In short, without time, there would be no space and no life!

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