Toward Genetic Aesthetics:

Mutation of Bio Information and Generative Art System

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Premise

We propose the meaning and potential of “genetic aesthetics,” because bio information can inspire the aesthetic purpose of generative art. By examining the definition of generative art and the term *generative*, the conditions of generative art can be compressed as rule, autonomy, and system. Among them, a system is considered as a key element in generative art, because an artist transfers subsequent control to system. In particular, a genetic system is regarded as the highest position on the Gary Flake’s graph of complexity. The graph shows that truly complex things occur at a transition point between orderly things and random things. It is a nexus of bio information and generative aesthetics, because it confirms that unity and diversity are not mutually exclusive concepts. Here, noise of information theory and a mutation of biology have an important role to explain the aesthetic value within generative art. Thus, we analyze noise by using the Shannon’s binary entropy function, and then apply a mutation to that function. The analysis shows that the uncertainty due to mutations can create the biological complexity in keeping with the certainty due to redundancy. A mutation might be a factor to produce probabilities of innovation or deviation under the well-knit database of bio information. Bio information in terms of a mutation eventually can be more persuasive to explain the aesthetic value of generative art in that the aim of generative aesthetics is the artificial production of probabilities of innovation or deviation from the norm. A specific process that can lie beyond the artist's intuition can be derived from a specific factor such as a mutation. It can inspire computer-based generative art in the relative discussions on the noise of complex system. Accordingly, genetic aesthetics can present the ultimate aesthetic direction at which generative art aims.

1. Introduction: Generative Art

The term *generative* was used formally for the first time at the computer art exhibition of Georg Nees, *Generative Computergraphik* in 1965, Stuttgart, Germany. In the same year, Georg Nees and Frieder Nake used the term *generative* to identify their works produced from a computer program. After that, Manfred Mohr began to use the term *generative art* to connote drawings made from a computer program since 1968. On the other hand, Jack Burnham identified the new works as process art of post-Minimalism. In this brief trace of the term, we can get a sense that generative art has been confused with process art, computer art, electronic art, and so on. Such puzzles concerning the identity of generative art are often confusing for both of artists and audiences.

Celestino Soddu has tried to clarify that the generative approach is to operate with a preference of metadesign to design. The concept idea is that complexity is controlled by using an approach that follows the complexity procedures existing in nature and artificial worlds. The idea is related to the natural/artificial dynamic system. Accordingly, he has identified that the generative approach cannot use an array of data, but a set of different generative devices, like a set of different dynamic chaotic systems, that work together and use the unpredictable contamination each other to access to different point of view. [1]

Here, we have noticed that a system in the generative approach would be an essential element. It is remarkable that the artist can give over his/her partial or total subsequent control to the system. Actually a system is necessary for *autopoiesis* as Maturana acknowledged: he realized that what was indeed needed was the characterization of a kind of system which would operate in a manner indistinguishable from the operation of living systems. Philip Galanter also mentioned that the key element in generative art is the system to which the artist cedes subsequent control. [2, 3]

Therefore, this paper is on a detailed analysis of the system as the key element of generative art, and on a discovery of characteristics of the system which generative art can fit in. Next, we explore the meanings and the relationships between the noise in information theory and the mutation in biology, associating them with systems which can be applied to generative art. Finally, we propose the interrelationship between generative art system and bio information, using ‘generative aesthetics.’ In conclusion, we propose the meaning and value of ‘genetic aesthetics.’

2. Generative Art System

The dictionary definition of *system* is an assemblage or combination of things or parts forming a whole. Even if a system is broadly used in various fields, it is strictly used in thermodynamics. A system in thermodynamics means a precisely specified macroscopic region of the universe. All space in the universe outside the system is regarded as the surroundings or environment. A system is separated from its surroundings by a boundary (*Fig. 1*). Transfers of work, heat, or matter and energy between the system and the surroundings may take place across the boundary.

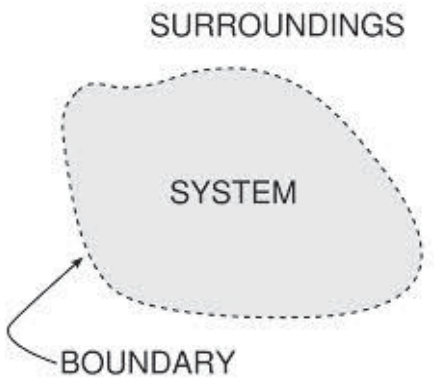

Fig. 1 - System-boundary

In the aspect of media, a system is a set of all real beings that operate in the inherent rule and associate with the surroundings. Simply put, a system exists in the universe, follows rules of the universe, and has an association with the surroundings. If we redefine a generative system, it can be an aggregation of components that form patterns based on mixtures of order and disorder, depending on the basic rule and autonomy. The fields utilizing generative systems are gradually expended by the development of the computer, from music and drawing to design and architecture. [4]

2.1 Category of Generative Art Systems

According to Galanter's view, generative art systems can be largely divided into three categories of ordered, disordered, and complex systems. He argued that the highly ordered systems is discovered in the several examples such as tiling used aesthetically in Islamic mosques, Maurits Cornelis Escher's use of the magical algorithms, and conceptual artists' uses of generative elements. The examples show that rules seriously affect their generative processes. On the other hand, as the highly disordered systems, he considered Wolfgang Amadeus Mozart's random combination of 176 measures, William Burroughs' cut-up-technique and John Cage's random selection of sounds. The examples show that autonomy has a decisive effect on their generative processes. [3]

Galanter has presented the graph of generative art systems in order to establish the relationship between complexity and order in generative art. This graph classifies from 'symmetry and tiling' to 'randomization,' following a degree of complexity and order. There are 'genetic system and A-life' on the highest degree point of complexity. However, there does not seem to be a method for measuring order and disorder practically, because it is never easy to analyze the states of generative art systems by utilizing quantification tools. That problem makes a question about the classification of Galanter. That is, it is doubtful not only whether he had good ground to classify generative art systems, but also whether he learned the reason why genetic systems are most complex.

2.2 Relationship between Generative Art System and Complexity

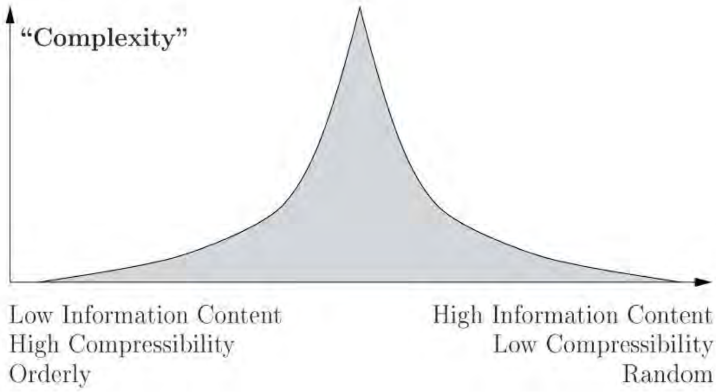

Fig. 2 - Complexity in terms of information, compressibility, and randomness

The complexity graph of Gary William Flake (*Fig. 2*) is more suitable to explain the relationship between generative art systems and complexity, because Flake's graph, the source of Galanter's graph, contains more fundamental contents related to information theory. In the graph, while 'orderly' is the concept related to low information content and high compressibility, 'random' is the concept related to high information content and low compressibility.

Above all, the graph shows that truly complex things occur at a transition point between orderly things and random things. While strictly regular things as well as strictly irregular things are simple, things that are neither regular nor irregular are complex. For example, while on one extreme of the graph is Euclidean objects which correspond to the orderly system for generative art, on the other extreme is pure noise which acts randomly. Meanwhile, mixed things of 'orderly' and 'random' such as Brownian motion seem to be complex. Brownian processes have memory in that every random injection is always made relative to the previous state. In Brownian process, a random injection implies a correlation of the current state with the previous state. It means that a rule as well as autonomy affects Brownian motion. Thus, it is possible to apply the conditions of generative art to the variables of complexity graph. The criteria of order and random can be derived from rule and autonomy. That is, generative art systems can be fundamentally classified, depending on the influence of a rule and autonomy. [5]

2.3 Complex System as the Ultimate Direction of Generative Art

A complex system has been across diverse studies such as physics, chemistry, biology, economics, sociology, and so on. Economists study a complex system in a stock market, biologists in a brain, psychologists in a mind, and ecologists in an ecosystem. A complex system is an inevitable point for many scholars who cognize the limits of existing world views, because those existing views are linear, dichotomous and mechanistic.

Complex systems have a lot of small components that interact with other components. These local interactions lead to self-organization without mastercontrols or external agents. Also, these self-organized systems emerge themselves, and adapt to the change of external environment. The crucial point is that the process is similar to the expression of bio information. Here, bio information is derived from bioinformatics, which is an interdisciplinary study of both biology and computer science. Since information is stored at a molecular level, it is closely related to genetic information. As the molecular level grows up step by step, emergent and complex attributes appear in living organisms. The process can be involved in evolution, because evolution as the core theme of biology accounts for the unity and diversity of life. Unity made by a rule and diversity formed by autonomy are eventually important resources of a complex system. [6, 7]

A cellular automaton is an example that shows complexity by using computer programs. All grid points called cells follow the same simple transition rule that specifies how each point interacts with its neighborhood. In cellular automata, all cells change their state simultaneously in discrete moments of time. The subsequent state of a cell depends only on the states of its adjacent cells. Accordingly, each cell functions like a little computer, repeating the same rule defining how to react to its neighbors. Cellular automata offer a paradigm for complex systems based on the local interaction of the cells and the iterative processing of subsequent configurations. Here, there is something that is inferred. The reason why generative art is based on computer programs is closely related to maximization of aesthetic value produced by the optimum combination of unity and diversity.

The ultimate direction of generative art system exists in the optimum combination of unity and diversity. It is beyond the level of complex systems such as Brownian motion or cellular automata. It is located at the very peak of complexity graph. Although the optimum combination of unity and diversity may create excellent aesthetic states, its realization cannot be easy. We do not know the identity as well as the method of optimum combination. However, as Soddu presented, it may correspond to natural-like complexity such as genetic systems. We may discover its evolutionary procedures and aesthetic clues by exploring information theory and biology. [1]

3. Mutation as Noise

3.1 Reason why Noise and Mutation are Important in Generative Art

At the very peak of complexity, we have hoped to find things such as the human brain and tried to invent things such as the perfect genetic system. However, it is difficult to realize the highest complexity in the current technology level of mankind. Rather, it is reasonable to assume that the highest complexity is not a target of realization but a target of conception. As Flake said, at a philosophical and scientific point of view, there seems to be something exciting happening between orderly things and random things. In particular, because 'orderly' and 'random' in the complexity graph are involved in information quantity, it is important to explore complexity in the aspect of information theory. Additionally, because information has been considered as the essential element of activity of life since the discovery of

DNA, biology is also important. Above all, noise of information theory and a mutation of biology are closely related to the reason why genetic systems can be located at the very peak of complexity graph.

3.2 Noise in Information Theory

In 1906, the simple formula $S = k \cdot \log W$ was inscribed on the grave of Ludwig Boltzmann who had brought a revolution to thermodynamics and information theory. He proved the second law of thermodynamics that the total entropy of the universe never decreases in course of every spontaneous change. The second law of thermodynamics was controversial by Maxwell's Demon in the view of statistics. After his death, Claude Shannon's information entropy theory not only played a key role to solve the paradox of thermodynamics, but also showed that information can become an object of physical rendition. Shannon was excellent in that he helped us find the answers concerning our simple questions with 'binary digit' or 'bit'. He introduced '1/0' as 'true/false', 'yes/no', and 'on/ off'. He also realized that a question with N possible outcomes can be answered with a string of $\log N$ bits. That is, we only need $\log N$ bits of information in order to discern a desirable answer from N possibilities. This is eventually connected with his theorems. Shannon's theorem has a strong influence, because entropy and redundancy are applied to them. [8]

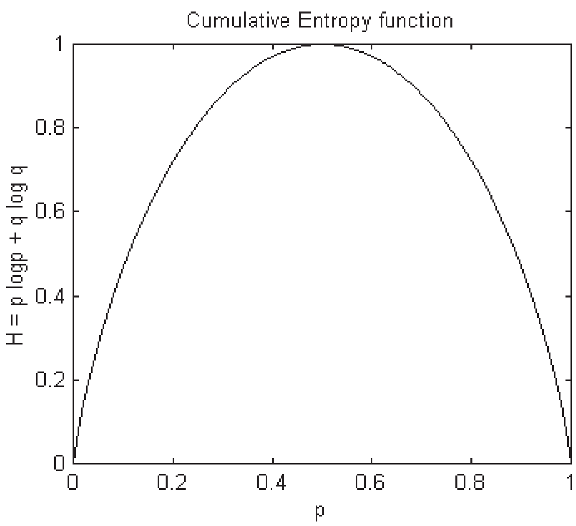

Fig. 3 - Entropy in the case of two possibilities with probabilities p and (1-p)

The more uncertain or irregular a string of bits is, the more a volume of information is. That is, the less redundancy a message has, the more information it can contain. On the other hand, the more predictable a string of bits is, the smaller a volume of information is. It is simply turned out by using the binary entropy function of Shannon. The entropy of the probability 'p' and 'q=1-p' come up with the function '$H = -(p\log p + q\log q)$', which can be expressed like the graph above (*Fig. 3*). As seen in the graph, in the point of 'p=q=0.5', the entropy is at the highest, and the amount of information is at the biggest. It means, when each probability of every symbol is same, the uncertainty and the information are at the largest. While Boltzmann's entropy is a measure of disorder, Shannon's entropy is a measure of information. [9]

Shannon explained Channel capacity theorem by using noise on the basis of his binary entropy function. The increase of noise means the growth of entropy, because noise augments the uncertainty. Meanwhile, the redundancy of desirable codes can become a way to reduce entropy. In this regard, even though the redundancy has to be augmented for errorless information delivery, it may decrease the amount of information. On the other hand, the accumulation of entropy owing to noise may make a volume of information grow effectively under the same error control capacity. Therefore, in the view of generative art, the amount of noise might be crucial to secure diversity and complexity, because generative art seeks unpredictable self-peculiarity under the basic rules.

3.3 Mutation in Bio Information

If we look into Galanter's complexity graph in the same context of Shannon's entropy function, we can infer the way to keep high complexity in genetic systems. Genetic information flows via transcription and translation as well as DNA replication. Information in cells passes from DNA to proteins as well as RNA. That is the Central Dogma of molecular biology. Shannon's information theory seems to be applied to the Central Dogma properly. Genes contain their information as a specific sequence of nucleotides in DNA molecules. Only four different bases are used in DNA: guanine, adenine, thymine and cytosine (G, A, T, and C). They are similar to quaternary numeral system codes. But we can think about them more simply. If each base has an allocation of 2 bits, four nitrogenous bases can be also substituted for 00, 11, 01, and 10. Furthermore, we can apply DNA double helix to the binary entropy function, using Erwin Chargaff's rules that DNA has a 1:1 combination ratio of Purine and Pyrimidine bases (*Fig. 4*). The complementary base pairing can be replaced with the binary numeral system, because the amount of G is equal to C's and the amount of A is equal to T's in the two strands of DNA. [6, 7]

Fig. 4 - DNA base pair binding

Now we can get a meaningful result from the graph of Shannon entropy. If the number of A and T bases and the number of G and C bases are equal in human DNA molecules, the amount of entropy and information would be the biggest on the graph, because the same occurrence probability as p=0.5, q=0.5 indicates the highest value of the graph. However, according to the Chargaff's rules, the four nitrogenous bases are present in these percentages: A=T≒30% and G=C≒20%. Applying this to the graph of Shannon entropy, we can get the high enough entropy value which is corresponded to p=0.6, q=0.4. But comparing with the highest entropy value which is corresponded to p=0.5, q=0.5, we need to consider the reason why human DNA base pairs are not composed by the proportion that can have an extreme high entropy value. The clue can be found out in a mutation.

In the late 19th century, a mutation was used to indicate a rare genetic freak found in Evening primrose by a Holland geneticist Hugo de Vries. It means a change in genetic information of a cell. Generally in biology, mutations are responsible for the huge diversity of genes found among organisms, because mutations are the ultimate source of new genes. Different versions of any given gene within a species of organism are known as alleles. Differences among alleles cover a broad spectrum ranging from those that are relatively innocuous to those that have very dramatic consequences. Change in the relative frequencies of these different alleles is the essence of evolution. New alleles arise from mutations occurring to an existing allele within a single member of a population. Therefore, the biological diversity is the diversity of the primary structure of DNA in essence, and its changes mainly depend on the mutation. The entropy is the best measurement for the biological diversity. Mutations can not only contribute to evolution by generating new factors, but also become a factor that increases the biological diversity. [7, 10]

Chargaff's rules reveal a problem of composition ratio in human DNA base pairs, compared to the maximum entropy probability distribution of Shannon entropy. Redundancy in the genetic code, however, has different influences on entropy. As redundancy is used to deliver information effectively in Shannon's information theory, redundancy is also used to translate genetic information effectively in the Central Dogma of molecular biology. RNA is made from DNA molecules during the transcription. There is 1:1 correspondence between the nucleotides used to make RNA (G, A, U, and C: "U" is uracil) and the nucleotide sequences in DNA (G, A, T, and C). Next, proteins are made from the information content of RNA molecules as they are translated by ribosomes. During the translation, ribosomes use a triplet code in order to translate the information in RNA into the amino acid sequence of proteins. Each group of three nucleotides in RNA is called a codon, and corresponds to a specific amino acid. Thus, there are 64 possible combinations (4×4×4=64) made from 4 different bases (G, A, U, and C) in RNA. However, despite 64 different codons, there are only twenty amino acids. It is the redundancy in the genetic code, because one amino acid can correspond to several codons. For example, glutamic acid is specified by both codons GAA and GAG.

The redundancy in the genetic code can decrease the entropy within a cell, in order to communicate clearly, using a lot of information produced by simple quaternary numeral system codes. On the other hand, as Shannon's information theory shows, it is effective to increase the information capacity owing to noise under the same ability to control errors. In the same context, biology including the evolutionary theory shows that it may be effective to expand the capacity of the uncertain information such as mutations. The uncertainty due to mutations can create the biological complexity in keeping with the certainty due to redundancy.

We could connect the high complexity of genetic systems with the generative approach Soddu has identified. The high complexity and unpredictable self-peculiarity obtained under the basic rules can be related to the selections exploding the artist/designer identity. Furthermore, if we can expand the biological complexity into the aesthetic dimension, we could suggest several clues for interdisciplinary research including art, information theory and biology. [1]

4. Genetic Aesthetics: Generative Aesthetics of Bio Information

4.1 The Projects of Generative Aesthetics

Evolution as the core theme of biology accounts for the unity and diversity of life, and then proves how the genetic information expresses the duality of life's unity and diversity. Among them, mutations hold a key position in the huge diversity of genes. In the exploration of the aesthetic value within generative art, it is necessary to discuss mutations and its corresponding noise, because the information theory has already been discussed enough in the range of aesthetics. The discussion has been called *The Projects of Generative Aesthetics*.

In *The Projects of Generative Aesthetics*, Max Bense noted that "generative aesthetics implies a combination of all operations, rules and theorems which can be used to create aesthetic states." The system of generative aesthetics aims at a numerical and operational description of characteristics of aesthetic structures which can be realized in a lot of material elements. Aesthetic structures contain aesthetic information only in so far as they manifest innovations. The aim of generative aesthetics is the artificial production of probabilities, differing from the norm using theorems and programs. It is connected with the aim of evolution that intends to obtain the possibilities of innovation, securing diversity within unity. [11]

4.2 Generative Aesthetics in Molecular Biology

Bense's view reveals the potential to connect the generative aesthetic processes with the results of biology which considers evolution as the core theme. He extended the meaning of generative aesthetics to aesthetics of production. It made possible the methodical production of aesthetic states. It helps the generative aesthetic processes to be connected with the results of molecular biology's Central Dogma.

We can survive by dint of the results of replications and deliveries of genetic codes produced by specific rules and operations. In particular, DNA is well suited for biological information storage. Both strands of the double-stranded structure store the same biological information. Biological information is replicated as the two strands are separated. The two strands of DNA run in opposite directions to each other and are therefore anti-parallel. Within cells, DNA is organized into long structures called chromosomes. DNA can be twisted like a rope in a process called DNA supercoiling. Folding and coiling by specific operations transform a DNA double helix into a chromosome. Here, each chromosome shows the aesthetic states that have self-peculiarity despite their similar shapes (*Fig. 5*). Each homologous pair has the same shape by sharing the corresponding genes. Meanwhile, their subtle different shapes among chromosomes are caused by different inserted genes. Their different shapes and formations eventually affect their different functions. It is closely connected with the methodical production of aesthetic states. The results reflect both unity and diversity derived from rule-based steps and specific operations.

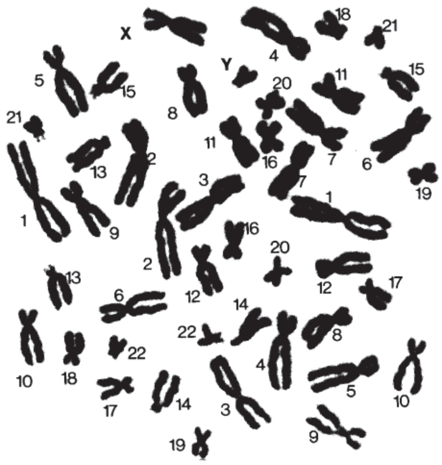

Fig. 5 - Human metaphase chromosomes

Proteins are large biological molecules which perform a vast array of functions within living organisms. A linear chain of amino acid residues is called a polypeptide. It refers to the primary structure. A protein contains at least one long polypeptide. It has directionality like DNA supercoiling. Specific operations help the primary structure to be folded and combined in order to form the secondary and tertiary structure. The last structure is referred to as the quaternary structure such as an active enzyme composed of two or more protein chains. Quaternary structure is the three-dimensional structure of a multi-subunit protein. Proteins create not only the basic aesthetic state of the primary structure but also various aesthetic states of the secondary, tertiary, and quaternary structure by specific operations (*Fig. 6*). They also show aesthetic states that have self-peculiarity. The folding and combining processes include a number of distinct and separate steps. The results imply both unity derived from rule-based steps and diversity caused by individual specific operations.

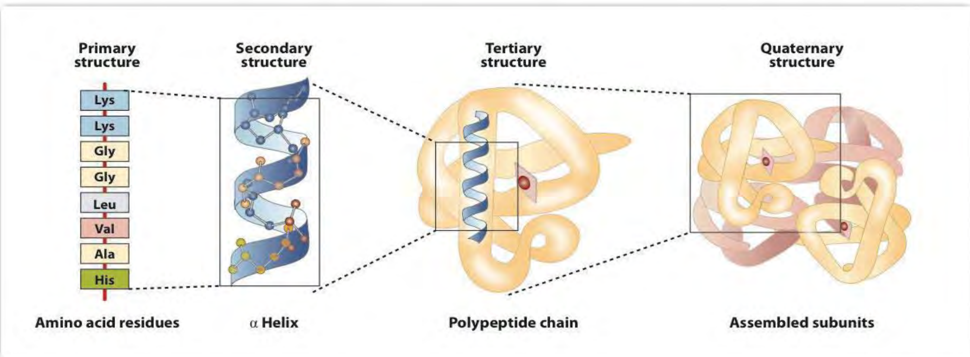

Fig. 6 - Levels of protein structure

The remarkable point here is that the structural figures of chromosomes and proteins represent high complexity formed by local interactions of small components, autonomic self-organization, and emergence. This is analogous to the ultimate aesthetic state that generative art concludes through complex systems. Therefore, bio information can not only be involved in creating material components such as DNA or amino acid as well as physical aggregations such as chromosomes or proteins, but also implies a combination of all operations, rules and theorems which can be used to produce unique distributions and configurations. This view meets Bense's generative aesthetic point of view. That is, bio information's self-peculiarity, represented by obtaining the autonomy and singularity under the basic rules, satisfies generative aesthetic aims. These aesthetic states, exposed by a combination of all operations, rules and theorems, help us understand why a genetic system can be considered as a highly complex state.

We can now review the relativity of generative art system to bio information by utilizing generative aesthetics. As seen in the organized *table1* below, our main themes are divided into two parts, the macroscopic dimension and the microscopic dimension. The dynamic entanglement of two dimensions infuses life into three themes of generative aesthetics, complex systems and bio information. Genetic aesthetics begins from putting genetic systems on it.

Table 1 - Contents of two dimensions in generative aesthetics, complex systems, and bio information

	Macroscopic dimension	**Microscopic dimension**
Generative Aesthetics	rules and theorems	operations of agents
Complex System	basic rules	interaction, self-organization, emergence
Bio Information	central dogma	operations of material components

4.3 Genetic Aesthetics

Bense said that "the aim of generative aesthetics is the artificial production of probabilities of innovation or deviation from the norm." Here, 'probabilities of innovation or deviation' is considered as an important point. We need to ask whether the complexity of a genetic system can be completely described by only interaction, self-organization and emergence or not. As shown in the figure below (*Fig. 7*), 2346 proteins (marked dots) and their interactive networks (connected lines) in a drosophila (a fruit fly) cell make the complexity come into sight. In fact, even if the content of this picture is complex enough to have difficulty in identifying respective dots and lines, this complexity just comes from a set of operations within the huge database. In other words, there is no specific factor to produce probabilities of innovation or deviation in this picture. [11, 7]

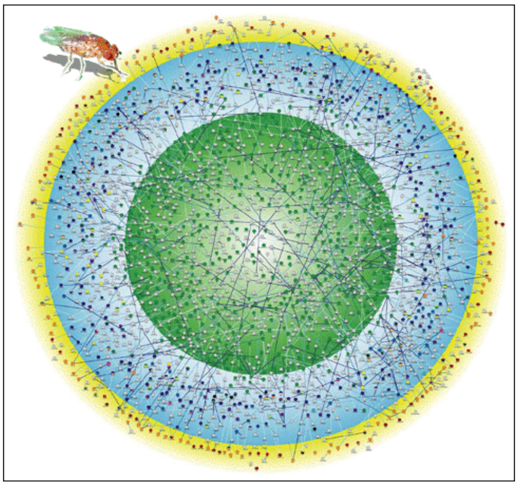

Fig. 7 - A protein interaction map of drosophila

A mutation is the possible factor which can solve that problem. It may be regarded as the element which can lead to super high complexity. We have already confirmed that some degree of noise under the same ability to control errors can bring about the effective increase of the information capacity. We have also thought that from the mixture of Chargaff's rules and Shannon's binary entropy function, the lack beside the highest entropy value could be an empty seat to accommodate other information like a mutation. A mutation eventually might be a factor to produce probabilities of innovation or deviation under the well-knit database of bio information.

Eduardo Kac has utilized such characteristics of mutation in his artworks. *Genesis*, produced in 1999, is a transgenic artwork that explores the intricate relationship between biology, information technology, dialogical interaction, and the Internet. It includes a synthetic gene that was created by translating a sentence from the biblical book of Genesis into Morse code and converting the Morse code into DNA base pairs according to a conversion principle developed specifically for this work. The *Genesis* gene was incorporated into bacteria, which were shown in the gallery. Participants on the web could turn on an ultraviolet light in the gallery, causing biological mutations in the bacteria. After the show, the DNA of the bacteria was translated back into Morse code, and then back into English. The mutation that occurred in the DNA had changed the original sentence from the Bible. In the context of the work, a mutation is a factor to cause innovation or deviation under the database of bio information. [12]

Here, a specific process that can lie beyond the artist's intuition can be derived from a specific factor such as a mutation. Thus, the biological aesthetic states created from the specific process might accord with the aim of generative aesthetics, because they embrace the deviation as well as the norm. The aim of generative aesthetics can be similar to an information system which expansively accepts noise under the same ability to control errors, and to a genetic system which expansively accepts a mutation in order to arrive at the super high complexity. Here is the real reason why genetic systems can be located at the very peak of the complexity graph. Therefore, genetic aesthetics does not only show the form of the highest complexity that computer-based generative art desires to express, but also present the best method for arriving at optimum combination of unity and diversity.

A potential factor such as a mutation now can be added to the microscopic dimension of the previous table, and then provides a clue that can connect generative aesthetics to genetic aesthetics. Aesthetics of Richard Shusterman as well as Bense's generative aesthetics inspired us to establish genetic aesthetics. Shusterman suggested that the complex cluster of disciplines devoted to bodily beauty and the art of living be today's aesthetic alternative for the ends of art because the end of modernity's artistic monopoly could augur some vibrant new beginnings for different forms of art. [13]

As Shusterman considered the human body as an essential in the art of living, we can connect the gene expression to the fundamental aesthetic states of our body and living. In the context of the vibrant aesthetic alternative, the collaboration project *Metallic Genesis* currently ongoing reflects the gist of genetic aesthetics. Even though Kac utilized the characteristic of a mutation in his work *Genesis*, it did not have the morphological concept of aesthetic object related to a mutation. Meanwhile, in *Metallic Genesis*, the sculpture suggestive of human body shows complexity including the characteristic of a mutation. Furthermore, while *Genesis* expressed the characteristic of a mutation through external participant involvement, *Metallic Genesis* reflects it by using internal residual energies. In fact, *Metallic Genesis* is derived from the biomorphic art *Metallic Communication* // created by Eunju Han in 2012 (*Fig. 8*).

Fig. 8 - Metallic Communication //

Fine copper wires and shape memory alloys utilized as its formative material play roles to bring the artwork to life by providing electronic energy. The state entangled by copper wires and shape memory alloys are taken to *Metallic Genesis*. It looks like a chromosome formation made by DNA coiling. In the flow of electronic energy, a conversion principle developed specifically for this work can help the specific human DNA sequences to be converted into Morse codes. The converted Morse codes control directly the flow of energy and affect the physical movement of the sculpture.

Then, when the power supply is cut off, the overall shape can be unpredictably changed by memory effect and elasticity of shape memory alloy only using internal residual energies. It is the genetic aesthetic form which reflects an unpredicted element such as a mutation under the database of bio information.

Therefore, in the genetic aesthetic point of view, we can separate out the specific aesthetic object such as the expression of genetic information, and connect with our living by observing them and leading to aesthetic experiences. As a result, genetic aesthetics can be referred to as the innovative combination of bio information and complex system within generative aesthetics. We need to recognize the potential of genetic aesthetics, because it might offer a convincing explanation for dynamic entanglement of our lives.

5. Conclusion

The recent argument over junk DNA shows clearly what the discovery of new values means. The term *junk DNA* means the portion of a mammal genome sequence which no discernible function has been identified for. This seemed to be presumptively proven in 2000 through the Human Genome Project. The project announced that a significant portion of human genomes accounts for only a very small fraction (1.5%) and the rest (98.5%) is associated with junk DNA. However, the results of the ENCODE project, which was published in Nature in 2012, rediscovered junk DNA as some degree of functional elements. In fact, we should be alert to the possibility of making over-interpretation about the meaning and function of junk DNA, because this part is still an unknown world under the current technologies of genetic engineering. Nevertheless, the rash conclusion such as junk DNA might often occur around us, because we have a narrow sight and knowledge. [14]

In the future, due to the expansion of acceptable range, we might discover the secret of super high complexity created by an optimum mixture of unity and diversity. Even if it has not yet been revealed in fields of science and technology, it might be always the goal and object of art. Thus, it is natural that generative art aims at high complexity created by an optimum combination of a rule and autonomy. It does not simply focus on how it copies a genetic system, but how it creates the aesthetic states by comprehending noise and mutation. This view shares Bense's context. The aesthetic structure has a specific meaning only by showing innovation which does not imply the fixed reality but the probable reality, and thus the guiding motif of generative aesthetics is to yield probabilities deviated from the norm through theorems or programs. Here, yielding probabilities deviated from the norm might be connected to the view of Soddu and Colabella. As they mentioned in the last conference, the most important reason why we approach art using the generative way is in the relationship between the generative approach and the human creativity. When the artist creates a generative dynamic artwork able to generate variation, he is able too to create a representation of his own idea. It entails the acceptance of mutations as well as the processes including interaction, self-organization and emergence. Thus, bio information is worthy of generative art by itself, and then being involved in generative aesthetics, it can evolve into genetic aesthetics. [15]

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