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Interactive Media Art based on Bio-mimesis for the Ecosystem

Dong-Jo Kim[1], Sang-Hwa Lee[2]*

Abstract

Ecosystem is composed of the considerably diversified living organisms. Those living organisms have their own movements distinctively and individually. Their movements keep evolving through the interaction with environment performed to survive and reproduce. The living organisms also have evolved through optimization process occurring over a long period of time from generation to generation. In studying phenomena or structures appearing in this process, the studies on bio-mimesis are essentially required. Since a research on bio-mimesis is based on an analysis for structures and functions of a living organism, new technological development is required to be promoted with aid of the cutting-edge technologies. A morphology based expansion for ecosystem is under development in a wide variety of fields ranging from Velcro to bio-mimetic robot. There are the studies being conducted focusing on movements of the living organisms as well as structures and functions of their appearances. It can be seen from a recent case study on an analysis of movement of underwater creatures for the purpose of reducing resistance in water or air. This process is also being researched in media art field. In this study, the interactive media art works that were produced by imitating various movements of living organisms occurring at ecosystem are investigated. The aim of this study is to explore characteristics of the interactions presented in those art works.

Keyword : Ecosystem, Interaction, Bio-Mimesis, Organism, Interactive media art

1. Introduction

All living organisms have their own movements that occur through an interaction with environment. Through these movements, their structures, principles, mechanisms and systems evolve and the reasonable algorithm is formed by means of an optimization process occurring in conjunction with external environment[1]. The case studies that have been conducted so far indicate that some movements of the living creatures can be referred to as this process. For examples, there are movement of ants when they transport food to their nest via the fastest route, movement of bees when they collect honey, movement of fireflies when they synchronize their flashing light by controlling it individually, and movement of living organisms such as birds and fishes when they move in group together[2]. The algorithms designed from an analysis of these movements are being developed and devised in various fields[3].

1 Graduate School of Game Gachon University, Seongnam-si, Gyeonggi-do, Korea [Professor]
e-mail : sojudj@gmail.com
2 School fo Manhwa Contents at Chungkang College of Cultural of Industries, Icheon-si, Gyeonggi-do, Korea [Professor]
e-mail : gomawooi@naver.com (Corresponding Author)

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While the living organisms pass through numerous generations continuously doing activities for survival and reproduction, the advantageous traits emerge and are established. The adaptation to new environment brings gradual evolution. The living organisms are reproduced through variation and nurtured by natural selection that happens as a reaction to environment. In biology, an evolution is a process through which biotic community accumulates variations from generation to generation, changes overall traits of the community and further gives birth to new species. All known species of today are descended from a common ancestor or ancestral gene pool through gradual divergence in this process. The principal mechanism of evolution is that traits of living organism are selected by interaction between biotic community and environment. The advantageous traits contributing to adaptation to environment are passed down to next generation, while the disadvantageous traits disappear. At present, the researches on evolution are still being conducted in in-depth and a variety of ways. Moreover, the studies on evolution are being positioned as a core principle in systemizing biology. Living organism accumulates advantageous variation by adapting itself to the given environment. The results emerging from the optimization process lead to a tendency that all the creatures get more improved in accordance to environment. As a whole, this improvement inevitably contributes to a gradual advancement of the systems for numerous creatures which inhabit the earth. The individuals that are well adapted to environment among creatures could survive well and give birth to more descendants[4]. By imitating movement of living organism in ecosystem, it is possible to design the algorithm which could produce the natural movement that is consistent with human's empirical recognition. The algorithm suggested in this way involves the characteristics of interaction and is expressed through biotic movement. Like biotic movement, the interactions with audience appearing in the interactive art indicate which influences would be exchanged in the given environment between audience and the art works and whether the feedback system would be formed. Investigating the process how the algorithm derived from the movement of living organism forms ecosystem within the interactive art works and how it recognizes audience as an external environment, this study will perform aesthetic considerations.

2. Relevance of interaction with ecosystem

In computer science, the term interaction is generally used to refer to a way of controlling and responding between user and system. In narrow sense, the computer being operated via manipulation using keyboard and mouse can be said to be an interactive machine. However, the interaction in this study means that user is able to directly control components consisting of story such as plot, characters,

behavior, time and space within a variety of forms of arts including story's structures[5]. To achieve this type of control, important things are how frequently the interaction takes place and how diversified options are provided to users in this interaction. This pursues not only simplified system architecture but also organic architecture. Actually, the interaction might affect contents of story or program and make change to overall flow of story[6]. However, since the interaction is a concept of putting two parties (audiences and art works) at each side and focusing on the relationship between two parties, it is a somewhat ambiguous and naive concept for revealing what contents and characteristics the interaction has and what change will be caused by two parties at each side. For the purpose of describing the changes occurring at audience's characteristics in art works which adopt story structure, there are two concepts: a playability and a performativity. Although the characteristics of both concepts are similar to the concept that comes from an analysis of computer game, they are different from each other. The playability focuses on a mechanism of psychological assimilation that happens due to direct interface of control and response, while the performativity focuses on an aspect that a player plays a central role in story telling process. These concepts eventually emphasize that consumer takes a double-sided nature in new form of art, that is, a spectator and a player at the same time. The virtual environment built by a computer programming algorithm is now being applied to the art so that it appeals to audience with strong impact[7]. Similar to the process of generating mutation, various images can be created by imposing an artificial manipulation to the program. Furthermore this method can be advanced and used for creating various living creatures and building a virtual world within computer. This technique has changed the existing art methodology in a fundamental way. While the art has been considered a creative behavior completed by artists so far, the method described here chooses the way of cultivating the art. Digital technology that is responsible for the interaction in the art attempted its application to the expression of the individual spirit. Unlike the traditional artistic expression which focused on showing and presentation, this implies that new paradigm is created in the art. In other words, the world where information digitization and interactive conversation are possible is associated with a form of expression oriented towards the inner world of human spirit by means of different composition of work from the traditional media which is based on intention and its understanding included in information exchanging between sender and receiver[8]. In reality, novel ecosystem is already being built in the interactive art and consistent communication is being carried out through them.

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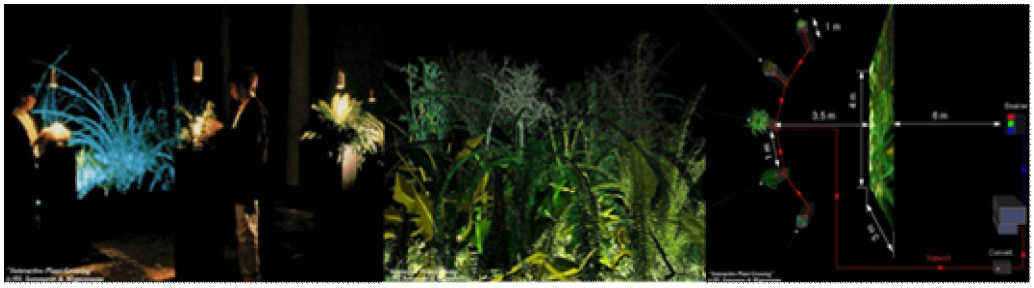
3. Case study on biotic movement based interactive art

Humans are being affected by ecosystem consistently. Over a long time, they have been performing their artistic activities in a variety of ways after obtaining artistic inspiration from natural environment. Since humans inevitably perceive other living creature's movements visually, this environment brings familiar empirical recognition to people. Therefore, lots of interactive art works were created by imitating movement of living organisms. In this study, several works in which the movements are constructed via interaction with audience will be investigated.

Firstly, the [Fig. 1] shows Interactive Plant Growing exhibited in permanent collection of the ZKM Media Museum, Karlsruhe. This work was produced by Laurent Mignonneau and Christa Sommerer in 1992. In this work, the real living plant is positioned with a screen which shows virtual environment images as background. When a viewer closely approaches or touches the plant, various virtual plants emerge and grow at the screen. This work was produced with use of a tiny amount of static electricity existing in human body and plant. When people touch the leaves, the change in static electricity occurs. This work was designed to detect this change using the sensor being attached at the plant's root and transmit the signal. Then the signal triggers the animation. In this case, a person's specific movement is associated with distinct animation. The distinction of information about static electricity held by the viewer is detected and is used to trigger the associated animation. This technique allows the viewers to see that virtual plants grow in real time at the screen[9]. They would feel familiarity from the virtual environment being presented in the screen, based on their empirical knowledge of the process how plants grow in reality. Furthermore they would perceive that the movements done by virtual plants shown in the screen are generated by imitating the real plant's growth process. As a result, the interactive actions applied to real plants by audiences are considered as the behaviors for virtual plants. This effectively lets them immerse in the work. While controlling movement of virtual plant that shows similar movements to real plant corresponding to the interaction, the audience acquires new experience through the art.

The virtual plant grows in the virtually created three dimensional space based on the algorithm developed in accordance with various morphological characteristics of real plants. The algorithm was developed using random parameter that seems like an artificial growth and differentiation regulator. This variable determines the morphology by controlling its morphological change. It changes in a way of defining an arbitrary variable for size, rotation, motion, angle and color of a plant. The electrical

potential difference between human and plant is measured through the living plants. This potential difference varies depending on the size and morphology of the real plant. The sensitivity of the plant ranges from 0 to 70 cm in space. A special protocol between computer and converter makes sure that each data value coming from each plant is synchronized and interpreted in real time by means of the growing program during the drawing of the virtual plants. All data values are interpreted as variables in the growing program. Each value corresponds to specific growing events such as rotation, scaling, location and change of color. The feedback of the virtual growth on the screen allows five or more people to interact at the same time with five real plants in real time in the installation space.



[Fig. 1] Interactive Plant Growing, Laurent Mignonneau & Christa Sommerer, 1992.

The [Fig. 2] shows the work named Portrait on the Fly – Interactive which is the latest work by Laurent Mignonneau and Christa Sommerer. A swarm of a few thousands files are shown in the monitor. When a person approaches and stands in front of the monitor, the swarm of flies builds up the contour of the person based on the image captured by camera in real time. The viewer gets immersed in the movements of virtual flies that are produced by imitating movement of real flies. While imitating flies movement existing in real space, this work controls flies movement through interaction between art work and viewers. The person's own image shown in the monitor is generated by flies and the person watches his/her own image filled with files[10]. This work suggests that the effect coming from the existing knowledge that have already been obtained from the real files movement disrupts unfamiliar feeling from new experience, and even contributes to an increase of the sense of immersion[11].

This work was carried out as a study on hierarchically expressing contour information coming from the real time image. An object is expressed with a basis of contour from the perspective of visualization in a computer graphics. Most of the contour-based image analysis algorithms present and use the contour information in pixel or segment unit. In the structured recognition or model based recognition technique, relationships between segments, and surface and segment are necessary. The

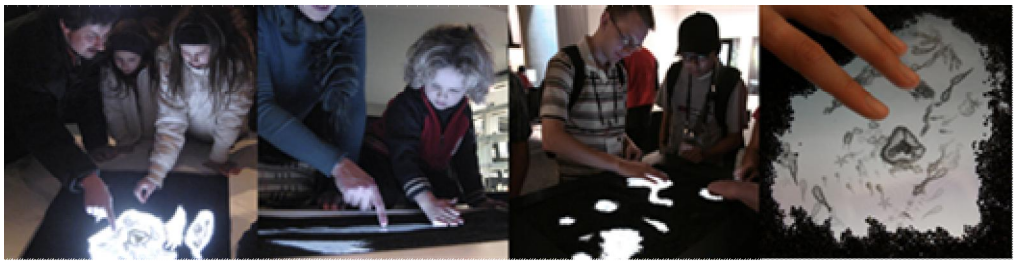
presentation of those relationships enable the efficient management of data existing at various dimensions from one-dimensional vertex to three-dimensional volume. Aside from that, inheritance relationship makes it easy to identify relationships of basic elements such as vertex, edge, line and region. The relationships are used to analyze the image. Based on this, the coordinates of a fly object are set and the scope of random motion is specified as the variables. Motion of a fly object is defined as a separate class and randomly presented to users by designating the presenting order of several images. The contour detection for the images of viewer is carried out with small delay, which is a useful technique to implement the movement of flies in more natural way.

[Fig. 2] Portrait on the Fly, Laurent Mignonneau & Christa Sommerer, 2015.

The [Fig. 3] shows Oasis produced by Everywhere (Huh, Yun-sil and Bang Hyun-woo) in 2009. The concept of this work is to remind the viewers of their memories of playing with sands and soils when they are young. If the viewers skim a part of sand particles at the screen where sands are placed, an image presenting an artificial life is created in the virtual lake and it moves. The virtually created living creatures are generated by imitating movements of underwater creatures from a real ecosystem. It shows that the creatures form a group, survive and are reproduced according to the law of the jungle. This work allows the viewers to give an influence to the survival of the virtual living creatures by controlling the size of the virtual lake[12]. Movement of underwater creatures have the characteristics of swimming or moving in clusters under the water. This work was produced by imitating these movements[13].

This work was implemented with use of depth sensor installed under the table. Analyzing the data transmitted by this depth sensor, the space with no sand is calculated. Then the virtual living creatures are generated and move around in this empty space. When the virtual creatures are simulated, they are designed to follow several rules in moving. While they encounter sand particles during swimming, they are supposed to adjust their moving direction to avoid collision with them. To achieve this, their movement is determined using an obstacle collision avoidance algorithm which is designed to return true

if no object representing a sand particle exists at the direction of their moving so that they can move to their direction[14]. Video simulation shows that a living creature successfully detects and avoids a sand particle by modifying its moving direction[15]. Additionally, if the space without any sand is expanded, the number of living creatures also gets increased because their moving paths can be more diversified.



[Fig. 3] Oasis, Everywhere, 2009.

The [Fig. 4] is series works titled Una Lumino by the artist U Ram Choi who is performing a study on mechanical living thing. This work was generated by imitating the shape of flowers. Their movements imitate the process how flowers bloom and fall. Several different flowers move in different speed and exist as mechanical living things[9]. Though the mechanical living things move in a group, they individually exist like real living creatures. To suggest that they exchange information with each other, this work shows their interaction with other creatures. Although no interaction with audience occurs, it shows the interaction occurring between virtual living things. This is based on the empirical recognition held by audience for living organisms. Mostly, the movement of plants living in ecosystem is extremely slow so that we cannot even notice. Even though the moving speed is different from the real world, it is indicated that the implementation imitating the process of moving the plant effectively contributes to an increase of immersion to this work.

Technically speaking, this work consists of the robot's joints to imitate repeated motions like breathing. The robot's joints are linked with a number of motors. Repeated motions are implemented by controlling them. If the mechanical joints are built with several motors, the amount of power consumption necessary to operate them would be considerably high. To minimize the power, pistons and gears were used in this work. The principle of motion is based on the biological flying creature. The muscles driving wings of insects or birds are connected to thorax so that they can operate wings making use of elastic recoil. Some muscles are used to adjust an amplitude or an angle of attack of the wings. Owing to these characteristics, insects are able to move their wings without much restriction with

rotational degree of freedom in three axis anchoring at root of the wing attached to thorax. However, there are very few models that can emulate such movement accurately. Generally, the manipulator having rotational degree of freedom in three axis is designed as a system in which drivers controlling other axe are serially connected at one axe. This method needs to occupy a considerable amount of the testing space that is required for wind tunnel test or tank test. It is also fundamentally different from the motion of insect's wings because each rotational axe does not start from the same point position. Additionally, this model is hard to be used to measure aerodynamics due to oscillation and sudden rotational motion since it is based on mechanical mechanism such as a cam, a cam shaft and a spring[17]. It is designed to use a stepping motor so that it could drive the weighty aircraft in spite of moving slowly. Fabulous and magnificent motion is successfully achieved with use of numerous gears and by installing them at some distance from rotational axe.

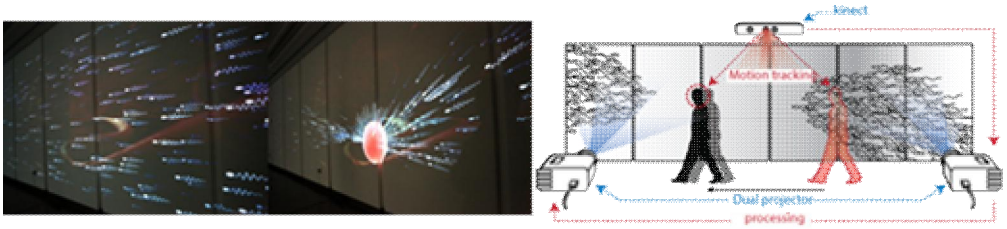
[Fig. 4] Una Lumino, U Ram Choi, 2008-2010.

The [Fig. 5] shows Sperm of the Artificial Insemination produced by artist Dong-jo Kim in 2012.

Individual movement of a sperm and its directional nature heading to an ovum in swarms were reproduced. Sperms were presented as screen image. An ovum was placed at the same route where the viewer moves so that this work makes the viewer and the ovum be identical. This work is an interactive media art using Kinect. It was coded using software called Processing. To make good use of wide space on wall in an exhibition hall, image was projected to the wall using two projectors. Kinect sensor is used to detect the location where the viewer is positioned. Once the sensor detects the viewer's position, it extracts and returns the coordinates. In the screen, a sperm object is generated, which flows to the left. If the viewer raise both hands straight up, the viewer's position is being tracked and an ovum is generated at the same position. Once the ovum is created, the sperms which were flowing slowly start to gather around the ovum[18]. The movements of the sperms are quite similar to those of micro living things that can be observed using microscope or living creatures

inhabiting the water. These movements are generally hard to be observed in real world, but people already have experience to observe them thanks to the technological advancement. The viewers could have prior experience by observing it using microscope or watching relevant images so that they can feel the sense of immersion while watching the sperms moving[19].

The sperm, basic component of a screen and the position of the viewer serve as the dynamic factor influencing environment. In the screen, the sperm that was artificially created exists. It was developed to reflect the viewer's position in real time basis. Motion of the sperm is expressed by changing the shape of its tail, while ovum images are generated according to the viewer's coordinate value that has been converted from the sensed data obtained by sensor. The behavior pattern of the sperm is implemented by applying constant values that are determined by the creation of ovum and the changes of coordinates. Once the behavior pattern of the sperm is determined, vibration starts from the sperm's head and is propagated to its tail. The sperm shows movement in a way of getting its driving force from its head's bending and tail's motion. The virtual sperm is generated by analyzing basic settings such as the vital power, the amount of movement and the position available to be distributed and applying various attribute values such as the movement, the interaction and the average data. To express the interaction occurring between sperms and ovum which is presented by reflecting the position of the viewer, the behavior type that senses direction of movement is applied with use of unique radius of the sperm's behavior. Since the sperm is an object that is the most dynamic and core element in this work, it is critically important to model the sperm's movement naturally. For crowd animation, verisimilitude of scene, performance of system and interaction with the viewer are emphasized in order to provide more realistic movement for the objects in the virtual environment. In the virtual environment where mob movement is required, the motion of the objects is automated[20]. This type of behavior including crowd animation imitates floating motion which mainly appears in sperms and underwater creatures.



[Fig. 5] Sperm of the Artificial Insemination, Dongjo Kim, 2012.

The [Table 1] shows a summary of the cases reviewed in this study. The movements of the virtual organisms were produced by imitating real organism's movement. Furthermore, they move with new

pattern through an interaction with the viewers and even show totally new movement that seems impossible in real organisms. Due to the imitating virtual movement, the viewers get confused at the boundary between real organism and virtual one and this confusion influences the immersion felt by the viewers. According to the [Table 1], the process of growing virtual plants in the first work occurs by the viewer's touch or approach. Though the viewers interact with real plant, the corresponding response happens at the virtual plant. From the perspective of the viewers who already have empirical recognition on how plants move from the real plants, it is natural that they require the identical response to the virtual plant. It could negatively affect the sense of immersion in terms of association.

[Table 1] Interactive characteristics based on imitation factors for each work

Title of art work	Movement of natural	Factors of the interaction
Interactive Plant Growing	Plant growth	Touch or approach of the viewer that is detected by sensing static electricity
Portrait on the Fly	Route through which flies move	Form the viewer's image using webcam
Oasis	Floating movement of underwater creatures	Move black coarse sands and form a space
Una Lumino	Blossoming process	Exchange signal information among virtual living things
Sperm of the Artificial Insemination	Floating toward ovum	Control the route through which sperm moves

In the second work, the route through which flies moves and the real behavior of the people are imitated and applied to the virtual flies. However, unlike the flies in real world, the virtual flies form the viewer's image as they fly in a group together. This is a scene that can never happen in real flies. The viewers provide the image to the virtual flies. As the viewers move, the images that are supposed to be built by the virtual flies keep changing. While the viewers keep reminding of phenomena they have experienced from the real flies, they watch the image that the virtual flies build by clustering. This work lets the viewers experience the intensive immersion as if they are controlling the flies. Although the virtual flies were produced based on the imitation of real files, it creates new phenomenon by allowing the viewers to involve the fly's movement via interaction. The third work shows a process that virtual organisms are generated and reproduced by imitating how underwater creatures float in the water. The movement of the virtual organisms feels familiar to the viewers because they recognize the movement through their prior-experience. The involvement by the viewer is more like manipulating the environment rather than directly controlling the movement of the virtual creatures. Once the space is

formed with black coarse sands, the virtual creatures carry out their generation and reproduction within the space. The viewers involve birth and death of the virtual creatures by providing or terminating the environment where they are contained. Additionally, they can control the scope of their living by adjusting the size of space. Though the virtual underwater creatures move by imitating real underwater creatures, the interaction in this work allows the viewers to experience new phenomenon that can rarely be seen visually in real world. Interestingly, the thing that this work was produced by imitating underwater creatures is a main factor to give the sense of immersion to the viewers. Thus a resistance encountering unfamiliar experience would not occur to the viewers. The fourth work imitates flower blooming image. This work attempted to differently interpret this blossoming movement, which is a signal information exchange between living things. Even though there is no interaction with the viewer, this work presumes the interaction among components in the work. The virtual organism was designed to move by imitating movement of the real flower. This movement expresses vital image of flower to the viewers. The viewers recognize the process how a flower blossoms and falls. Through this movement, they feel the life of the flower. The movement shown by the virtual living organism becomes the reason why the flower is embodied and why they exchange signal information with each other. It is indicated that imitation of real flowers includes even a process of embodying flower image. The viewers already recognize that an exchange of signal information takes place between organisms and between organism and environment in real ecosystem. For this reason, the movements shown in the virtual living organisms are considered to be in sufficiently strong position to the viewers. The fifth work imitates movement of sperms and ovum. The viewers already have knowledge on how the real cells move using scientific equipment called microscope. In real world, an individual sperm has its own movement and moves heading to ovum. By imitating this movement, the virtual sperm moves toward ovum uni-directionally. The sperms which continuously float are presented in the screen as images. When the viewers approach closely to the screen, the location of the viewer is sensed and tracked. At the position identical to the viewer's location, a virtual ovum is generated and the virtual sperms swim toward the ovum at the same time. If the position of the ovum changes as the viewer changes his/her position, the sperms also modify their direction so as to head to the ovum properly. In this work, the viewer plays the same role of the ovum. Eventually, the viewer can control the movements of the sperms and can get an interesting experience to make the ovum move in the virtual world, which does not actually move. Through this, the sperms would move in a variety of routes rather than monotonous path as the viewer moves. From this work, the viewers can visually experience the imitated movement of the virtual sperms based on their prior experience, which effectively leads to an increased sense of

immersion. Furthermore, the viewers will encounter unfamiliar scene at which they are able to change the position of the ovum, but they can naturally perceive this new experience that they never have before. Based on these analyses, the [Table 2] summarizes theses considerations in two perspectives: (a) the prior experience perceived from the imitated movement of the real organisms, which is a factor that amplifies the sense of immersion to the work, and (b) new experience felt by the viewer through an interaction with the work.

[Table 2] Empirical motion factor felt by the viewer in the work

Title of art work	Motion factor that had been experienced in the past	Motion factor of new experience
Interactive Plant Growing	Slow growth of plant	Plant's growing speed producing an immediate response
Portrait on the Fly	Behavior and moving route of the flies	Clustering for forming image
Oasis	Movement of underwater creatures	Birth and death of the organisms by environmental control
Una Lumino	Movement of flower blossom	Expression of embodied vital image of flower
Sperm of the Artificial Insemination	Movement of sperm floating	Control of the moving route of the sperms by changing their paths

4. Conclusion

In this study, five interactive media art works produced by imitating movement of living things in ecosystem including the work of this researcher, were reviewed and investigated. The analysis results indicate that the movements that have been produced based on the imitation of the real living creatures contribute to an increase in the immersion felt by the viewers in conjunction with an empirical recognition possessed by the viewers. Bio-mimesis increases the flexibility for the changes occurring at the virtual living things presented in the interactive media art work. Even though the virtual and real working environments are not consistently and perfectly specified, the works show reasonable performance with high scalability. In terms of necessity of more efficient decision-making in choosing the optimized movement for the virtual creatures, there are still lots of things to do in enhancing the techniques to develop creative images. Additionally, it is necessary to consistently conduct researches on the optimized motion corresponding to various interactions occurring at real ecosystem. Since the scalability of the ecosystem is affected by the range of initial values that are used in an algorithm to decide how the virtual living things move, it is critical to investigate the ecosystem in detailed way.

Moreover, it is necessary to have an integrated thinking with other fields in conjunction with profound understand of the ecosystem in the process of doing a strict mathematical analysis for the motion imitation algorithm. Bio-mimesis integrated with other fields could provide significantly creative basis in applying and making use of the algorithm[21].

The virtual environment where the virtual living things exist enables the viewers to apply stable affordance by building virtual ecosystem based on biotic movement. The control to the movements including biotic reproductive activity allows the viewers to get visual experience for the space that they would never experience in real world. In this process, empirical cognitive ability gets to work from the viewer's perspective. In this study, several cases relevant to movements of the plants and the underwater creatures were examined. It is also predictable that the use of art enables people to pursue the novelty in a way of reproducing or controlling the nature as a creator of the nature. It is expected that the analysis of biotic movement and bio-mimesis in this study could contribute to promoting aesthetic consideration for the interactive media art and lead to further study on bio-mimesis.

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