Timeaxis Design of an Email System for Sustaining and Deepening "KIZUNA"

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***Abstract*—In this research, we developed an email system designed to sustain and deepen "KIZUNA," by which we mean the precious bonds that exist between individuals and human relationships as one element of spiritual richness, based on a design concept of a KIZUNA Visualizer, intended to satisfy the user's need for spiritual richness, in response to the growing importance placed on KIZUNA by contemporary values. In the design process, we introduced a timeaxis design approach based on multi-time scale and a value growth process, as the design viewpoint to deal with the changes undergone by KIZUNA over time. We also introduced into the email system a self-organizing form-generation system based on bio-inspired design, which is one of the methodologies of timeaxis design. These design developments resulted in us determining to visualize KIZUNA through self-organizing, transforming icons as a design concept. We therefore created 6 functions to show changes in the state of KIZUNA through changes in the shape and color of icons made in correspondence to the exchange of emails. In addition to the proposal of the KIZUNA Visualizer, a new email system that visualizes KIZUNA, which resulted from this design process, we also produced a prototype of the KIZUNA Visualizer. After considering the effects of the system and its prototype from the viewpoint of value growth process, the potential of this system in maintaining and deepening KIZUNA was indicated.**

Keywords-Email; Timeaxis Design; Multi-time scale; Bio-inspired Design; Self-organizing

I. INTRODUCTION

The development of science and technology in recent years has made mass production and mass consumption possible; it has brought material affluence to our lives. However, it has been pointed out that increasing satisfaction with our material wealth has been accompanied by a shift from values that emphasize convenience and efficiency to those that place greater importance on spiritual richness [1]. Specifically, the pursuit of the individuality, including individual lifestyle choices, tastes, and interests, and pursuit of human relationships, such as placing priority on the time spent with family, have come to be more valued [2]. In this context, media content and products that can satisfy this enhanced need for spiritual richness are increasingly in demand.

We focused on the pursuit of human relationships as one element of spiritual richness, in particular, we focused on KIZUNA, namely precious relationships—bonds—between people. Japan experienced the Great East Japan Earthquake in March 2011, and in the same year the Japanese character for KIZUNA was chosen by public vote as the character most represents the events of the year; this suggests a growing consciousness of the importance of personal relationships. We developed a tool to aid the continuance and deepening of KIZUNA, which is so cherished in modern values.

In this research, we focused on the goal of satisfying modern human need for spiritual richness, working with the design concept of a KIZUNA Visualizer, a system to visualize human relationships. This KIZUMA Visualizer is a key to the development of an email system that enables users to sustain and deepen KIZUNA, by facilitating the visualization of the invisible bonds of KIZUNA. We aimed

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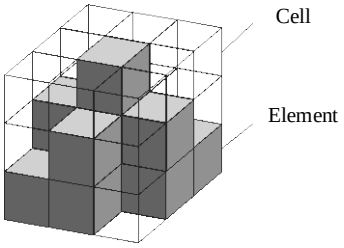
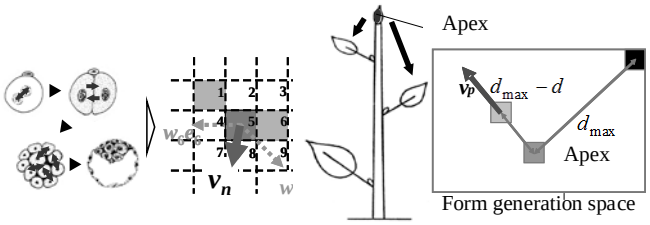


Figure 1. Cellular automaton



(a) Induction (b) Apical dominance

Figure 2. Input vectors

at encouraging users to notice changes in KIZUNA over time, and thereby, encourage and promote better communication. To realize this design concept, we needed to develop our design in a way that considered the relationship between the state of KIZUNA, changeable over time, and the email system. Therefore, timeaxis design [3], which incorporates a temporal axis into the design process, was integrated into the study as its central approach to design development.

II. SELF-ORGANIZING SYSTEM

This section describes the self-organizing email system based on Bio-inspired design.

A. Introduction of Bio-inspired Design

In this paper, we introduce the timeaxis design approach to design, based on the incorporation into design of a temporal axis. One of methodologies that can be used to actualize timeaxis design is bio-inspired design [4][5]. Bio-inspired design is a methodology that is able not only to mimic the structure of life forms but also to adapt to the changing diverse environments of life. By using this methodology, the target of the design is able to change the system itself, making it possible to accommodate changes in the values and usage environments of the user experienced over time. In this study, therefore, we modeled the developmental processes of life using cellular automata, thereby introducing a bio-inspired self-organizing system to generate a variety of forms as the technological seed of the proposed email system. This form generation system makes possible the production of an icon that can transform as it matures into a variety of shapes, as if it were artificial life. The maturation of this icon is linked to the communication conducted over email, and therefore can be considered as a method to achieve the visualization of our design concept of KIZUNA. In addition, in this study we conducted design development that took into consideration the relationship between the changes seen in KIZUNA in accordance with the development of the icon, directly linked to the email system, and the passing of time. The theory of timeaxis design [6][7] is incorporated in the design approach we chose.

B. Bio-inspired Self-organizing Systems

In this section, we discuss the form generation system used to generate the icons to visualize the state of KIZUNA.

The form generation system used cellular automata (CA), as shown in Fig. 1 [8][9], to generate various forms through self-organization. The CA is expressed as

$$C^{[t+1]} = f\left(C^{[t]}, N^{[t]}\right)$$
$$C = \left\{S_1, S_2, \cdots S_{n-1}, S_n\right\} \quad (1)$$

where, S_i is the state of the cell, $\boldsymbol{C}^{[t]}$ the cell state at time step t, and $N^{[t]}$ the status of neighboring cells at time step t, and f the transition function.

This system uses voxels to represent CA elements. Apical dominance and induction, observable as features in the developmental processes of organisms, were introduced as the state transition rules for CA [10]. Induction is the influence of one cell onto its neighboring cells, resulting in those neighboring cells changing to display specific traits. Such induction was modeled as a neighborhood information vector $\boldsymbol{v_n}$ Fig. 2(a) around the noticed element, and the equation is set as

$$\boldsymbol{v_n} = \sum_{i=1}^{26} b_i w_i \boldsymbol{e_i} \quad (2)$$

where, i is the number of the 26 neighboring elements adjacent to the noticed element, b_i is the existence of elements taking a value of 0 or 1, w_i is the integer, from 0 to 8, expressing the size of the recorded effect in the one-dimensional array created randomly for each form generation trial, $\boldsymbol{e_i}$ is the unit vector moving in the direction of the noticed element away from the neighboring elements. Apical dominance is the quality where the dominant element, known as the apex and in control of ontogeny, produces an effect on morphogenesis. This apical dominance was modeled as a locative information vector $\boldsymbol{v_n}$ Fig. 2(b) influencing the noticed element from the apex, and the equation is set as

$$\boldsymbol{v_p} = \left(d_{\max} - d\right)\boldsymbol{e_d} \quad (3)$$

where, $d_{\max}$ is the distance between the apex and the cell that is furthest from the apex, d is the distance between the apex and the element, and $\boldsymbol{e_d}$ represents the unit vector pointing the direction of the element from the apex. This means that the closer an element is to the apex, the greater the impact of

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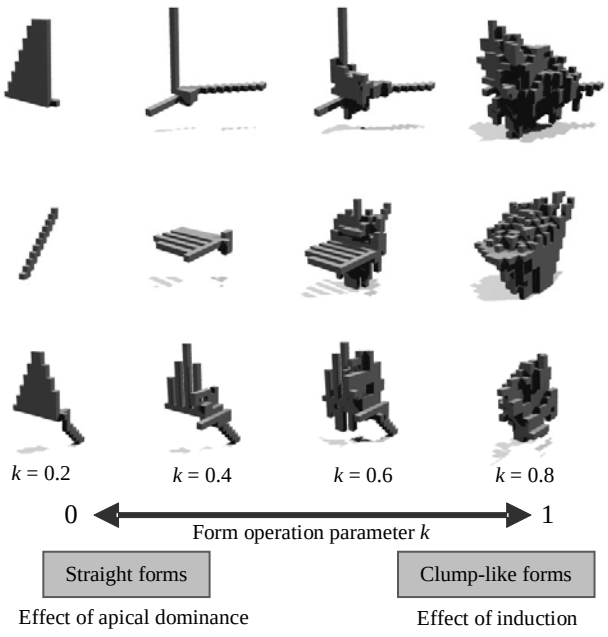

Figure 3. Changes in the features of generated forms

the apex on that element. Next, the CA input vector $\boldsymbol{v_{in}}$ is set as

$$\boldsymbol{v_{in}} = k\,\boldsymbol{v_n} + (1-k)\,\boldsymbol{v_p} \qquad (0 \le k \le 1) \qquad (4)$$

where, k is defined as a form operative parameter expressing ratio where two vectors are bonded. It is possible to adjust the rate of synthesis—the effect of induction and apical dominance—through the value of k. Fig. 3 shows the changes thus generated through form operation parameters of form feature. In equation (4), the closer the value of k is to 0, the stronger the apical dominance, meaning a constant, same-direction effect from the apex; this results in a tendency toward the generation of rod- and plate-like forms. On the other hand, the closer the value of k to 1 in equation (4), the stronger the influence of induction, meaning that multi-directional influences will be exerted by the elements surrounding the noticed element, resulting in the generation of clump-like forms [10]. The features of this system may therefore be useful in allowing us to impart meaning to the shape of icons representing registered users in our email system.

III. DESIGN DEVELOPMENT FOCUSED ON MULTI-TIME SCALE

In this section, we describe the design development process actually undertaken, based on a multi-time scale using a timeaxis design approach. We also dicuss each stage of the process.

A. Extraction of Design Elements

In this process, the design elements required to realize our design concept of the visualization of the state of KIZUNA were extracted. Elements describing state, such as the number ofemails sent and received, and the frequency of communication, and meaning elements, namely the visual changes in the icon representing registered users, were extracted. For the icon generation through bio-inspired self-organizing systems, we worked on the indivdiualization of each icon, and the extraction of meaning element, namely the offer of the enjoyment of not being able to predict growth.

1) Extraction of Time-related Design Elements: Design elements were extracted based on our design concept of the visualization of the state of KIZUNA; this allowed us to connect the meaning element of visual changes in the icon and state elements such as the number of emails sent and received and the frequency at which they were sent and received. These connections allowed us to construct a relationship between KIZUNA and our email system.

B. Element Classification and System Design

In this process, value elements required for the maintenance and deepening of KIZUNA and seminatic elements required for the visualization of the changing state of KIZUNA are classified. In addition, those design elements that were missing were extracted. The following outlines the specific details of the process. In this study, first, value growth process was introduced, and the processes of maintenance and deepening were divided into five phases, with existing value elements ordered within those phases, and the missing elements for each phase is extracted. The classification and extraction of value elements according to this value design process facilitated the clarification of the processes by which KIZUNA is deepened via this email system. Next, the multi-time scale and the value growth process were introduced, in order to classify meaning elements. We extracted additional meaning elements required in the context of our awareness of their relationships with the various value elements. This allowed us to build a KIZUNA visualization system using changing icons. This system uses icons that change according to information received from the email system of which they are part in order to visualize KIZUNA. The parameters that define the icons are threefold: element number, representing the depth of KIZUNA; transparency, representing the deepening phase of KIZUNA; and the element form features, representing the growth phase of the KIZUNA. Element number will vary according to the number of emails sent and received in short time. Transparency will vary according to the frequency at which email is sent and received in medium time. Element form feature will vary according to the number of emails sent and received and the frequency at which they are sent and received over long time.

1) Effects of Introducing the Multi-time Scale: Simply organizing meaning elements is not sufficient to understand their relationship over time, and further it is difficult to build a specific system. However, by dividing meaning space into

short time, medium time, and long time using a multi-time scale, and by clarifying the relationships that exist therein, it becomes possible to clearly order meaning elements in terms of their relationship in time. Specifically, we were able to organize elements in terms of their relationship with units of time; icon growth—according to the number of emails sent and received—is a meaning element in short time (seconds or minutes), transparency changes—corresponding to the frequency of emails sent and received—is a meaning element in medium time (hours or weeks); form feature change—determined by the number ofemails sent and received and the frequency at which they were sent and received—is a meaning element in long time (months or years). By organizing elements in conjunction with units of time, we were able to clarify the relationship between time scales and elements.

2) The Effects of Introducing the Value Growth Process: If aiming for artifice design that will increase in value over time, it is vital that the processes by which value can grow are clarified The introduction of the five-phase-value growth process in value space has the effect of helping to clarify the process of value growth, as well as to facilitate understanding of the values required at each phase. Specifically, we defined these values as: user expectation toward the new email system at the value discovery phase; user surprise at icon transformation at the value realization phase; joy at deepening KIZUNA at the value growth phase; satisfaction at the creation of precious KIZUNA at the value establishment phase; and a sense of security at leaving a record of their communication history at the value as tradition phase. By clarifying these processes, it becomes easier to envisage the scenes in which the email system might be used and the functionality required in those scenario. In this process, then, we introduced a five-phase value growth process, thereby making it possible to have a greater awareness of the relationship between scenanio and functionality and the growth of value.

C. Structuring Design Elements and System Refinement

In this process, in order to refine the system concept gleaned from the previous process, we structured the various design elements. The structurization of these elements focused on the relationship between the meaning elements that make up the KIZUNA visualization system that is at the core of our email system and state elements that are used in the expression of KIZUNA. In particular, we gave specifical numerical values to the changes in value in our three parameters of element number, transparency, and element form feature, as resulting from the meaning elements in our system. In addition to the extraction of the specific meaning elements that comprise convenience and aesthetics in GUI email systems, we also sought to extract as state elements the material properties required to realize those meaning elements. This process enabled us to refine the details of the design.

1) Parameter Settings to Express KIZUNA State: When structuring design elements, we integrated the meaning elements with physical state elements of the KIZUNA visualization system, and simultaneously set specific numerical values to express changes in physical state elements brought about by semanic elements. As an example, if the functional expression of the depth of KIZUNA in terms of the level ofemail sent and received, meets the pre-set condition of ‘send or receivemail’, the element number parameter is set to increase from 1 to 10 according to the volume of email. This method of parameter setting means that actual change can be described as numerical value change in parameter, thereby making changes previously difficult to anticipate from meaning elements alone readily understandable, as well as available to share. It also become possible to understand ongoing changes in parameters in accordance with the value growth process and multi-time scales; this can be considered as increasing the efficiency of actually building a system using a program.

2) Visual Configuation of the GUI: The visual appearance of the GUI is an important factor in determining the overall impression of any email system. Having described the maintenance and deepening of KIZUNA as the clear and specific goals of the system, it allows us to establish a visual concept for the GUI that reflected our design concept. Specific examples here include the positioning of icons in a circle, to recall the way that human relationships spread out like in circles and the use of a bird's-eye view perspective enabling the user to determine the status of all icons.

IV. KIZUNA VISUALIZER PROPOSAL

In this section, we describe the email system, entitled KIZUNA Visualizer, developed via the design development processes discussed in Section 3, as well as details of the six specific functions of the visualization system.

A. KIZUNA Visualizer: System Overview

Fig. 4 shows an overview of this email system. The system uses self-organising self-transforming icons to sustain and deepen KIZUNA, based on a core design concept of the visualization of KIZUNA. Changes in the state of the invisible interpersonal bonds between users are expressed through icons, thereby alerting the user to KIZUNA changes and promoting communication. The icons used to express KIZUNA visually are governed by three parameters: element number, transparency, and element form features. These three parameters vary according to the six functions indicated in Fig. 4, facilitating the visualization of KIZUNA as a result.

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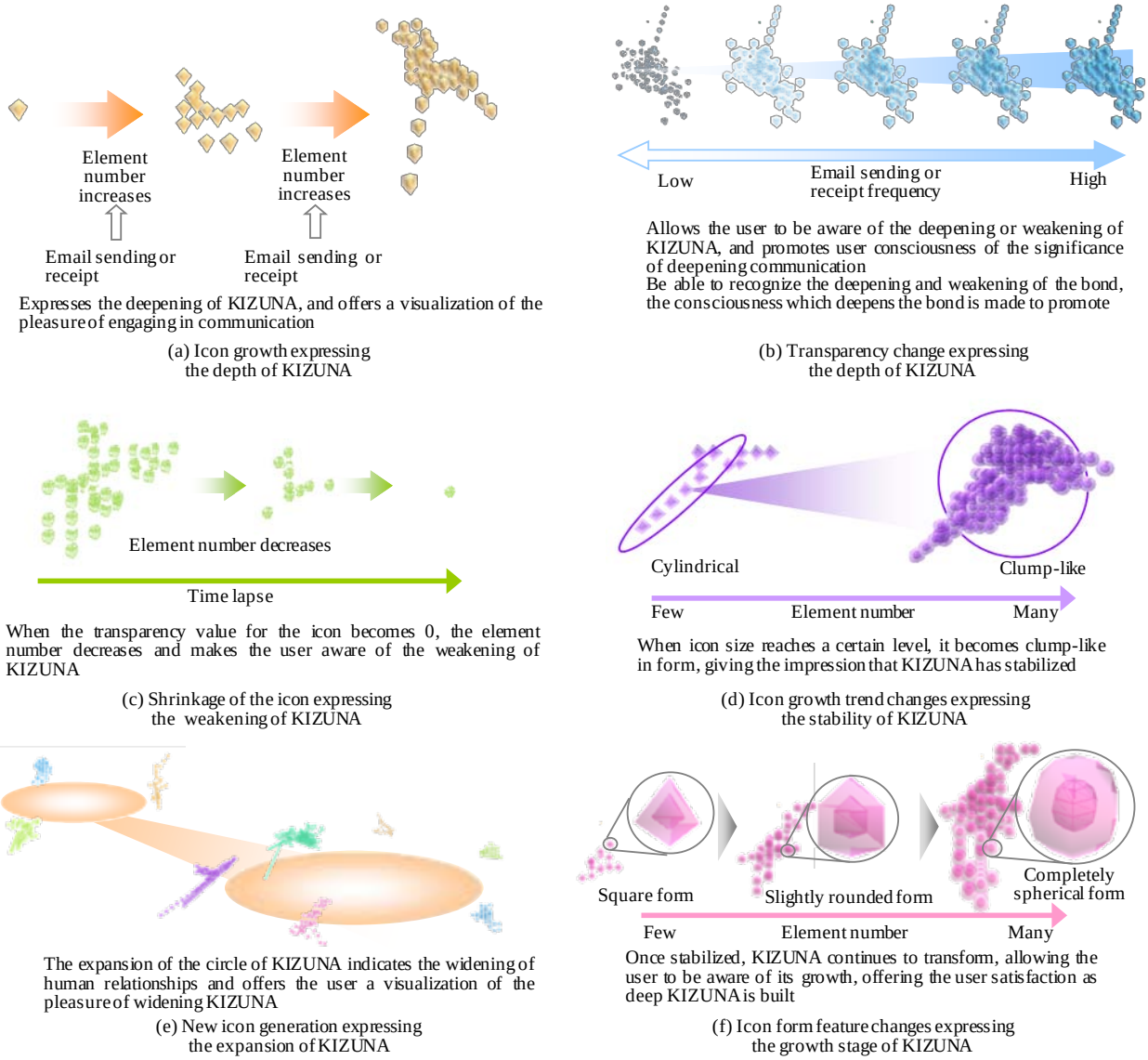


Figure 4. Six functional algorithms used in our system for the visualization of KIZUNA

B. *KIZUNA Visualizer: System Details*

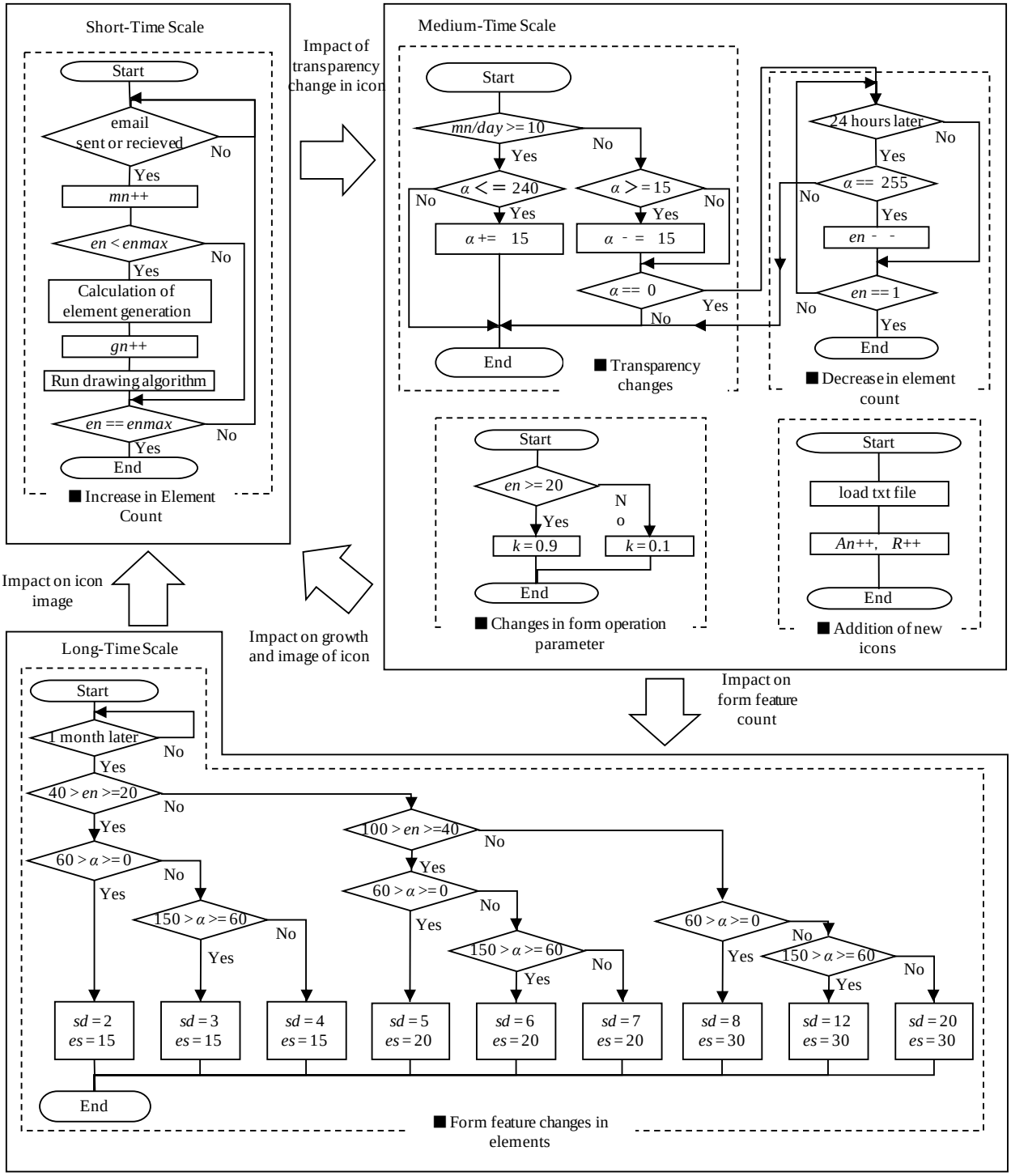
Fig. 5 shows the six functional algorithms used in our system for the visualization of KIZUNA. Here, we will give an outline of each time scale and an explanation of each of the six functions in the context of short, medium and long time scale.

1) Short-Time Scale: The short-time scale functions to increase the element number according to user action, in this case the sending and receiving of emails in units of minute.

When sending or receivingemail, where element number of the icon is less than the maximum element number 150, the bio-inspired self-organizing system will perform a calculation and the number element for the relevant icon will be increased by one generation.

2) Medium-Time Scale: In the medium-time scale, the increase in element number per day is calculated, and the transparency of the icon will change accordingly. The medium-time scale also functions to decrease the element number according to transparency, and to generate new icons.

a) Transparency Changes: Icon transparency takes a value between 0 and 255. Where the value is closer to 0, the level of transparency increases, where it is closer to 255, the icons become more opaque. The rules governing such change are set out below. When the number of emails sent and received in a single day is 10 or more, and the transparency value is less than 240, transparency (α) will



en :Element number
enmax :Maximum element number
gn :Generation number
R :Size of diameter on which icons are distributed
An:Icon number
es :Element size
α :Transparency
k :Form operation parameter
sd :Spherical polygon resolution of elements
gnmax :Maximum generation
mn :Number of emails sent and received
mn/day :Number of emails sent and received each day

Figure 5. Detailed breakdown of KIZUNA Visualization system

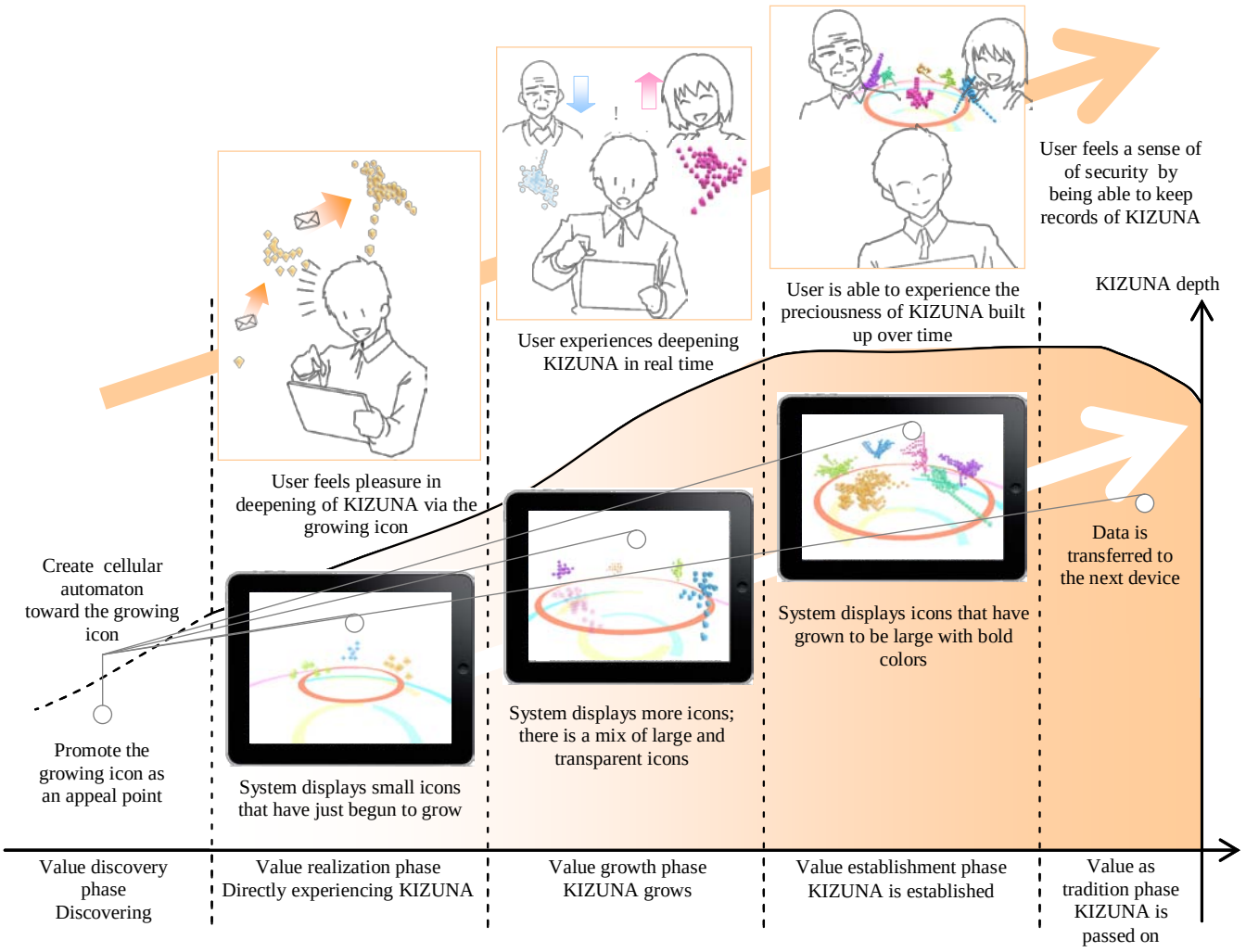


Figure 6. The deepening of KIZUNA through the KIZUNA Visualizer

increase by 15 points. Similarly, when the number ofemails sent or received in a single day is less than 10, and the transparency value is 15 or more, transparency (α) will decrease by 15 points.

b) Element Number Reduction: For every 24-hour period during which the transparency value remains consistent at 0, elements will be deleted one after another, starting with the more recent generation, to reduce the element number. Once element number reaches 1, the default position, the element will not be deleted even when the transparency value is 0.

c) Form Operation Parameter Changers: Changes in the form operation parameter *k* alter the growth trend of the icon. Specifically, where the element number is less than 20, the form operation parameter *k* is set to 0.1, the tendancy is for the icon to grow into a narrow, rod-like shape. Should element number increase to 20 or more, the form operation parameter *k* is altered to 0.9, resulting in a larger, clump-like shape.

d) Adding a New Icon: New icons can be generated by uploading a .txt file containing the name andemail address of themail correspondent to be newly registered. When a new icon is generated, the circle around which the icons are arranged expands to incorporate the new icon.

3) Long-Time Scale: In the long-time scale, the number element (increased in the short term) and the transparency (affected in the medium term) impact and alter the form features of the elements that comprise the icon.

After one month has passed, the resolution of spherical elements and the size of elements will change according to element number and transparency. The lower the element number and the closer the transparency value is to 0, the more the elements will appear rough and angular; the higher the element number and the closer the transparency value is to 255, the more the elements will appear large, smooth, and round.

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V. DISCUSSION OF THE KIZUNA VISUALIZER

Fig. 6 shows a conceptual diagram of the deepening of KIZUNA through the KIZUNA Visualizer. Here, we discuss the processes involved in the Visualizer through the value growth process.

- In the value discovery phase, it is necessary to create expectation toward the product in the user. During this phase, product demo videos should be shown in stores and on the web, encouraging users to discover the new conceptualization of interpersonal bonds being offered to them through the product, namely an expression of KIZUNA through transforming icons. This sort of activity should make it possible to increase user expectations.
- In the value realization phase, the user needs to use the actual product and realize its value directly. At this early stage, the icon is still small, and it therefore possible to inspire user expectation as to how the icon will grow and transform. It is also possible to create excitement in the user as the icon responds to the transformation of icons asemails are sent and received, and this allows the user to enjoy the deepening of KIZUNA.
- In the value growth phase, it is necessary that the user senses that the value of the product is increasing with prolonged use. By this stage, some icons will have grown large or very opaque due to frequent communication, allowing the user to gain a direct sense of the maturation of KIZUNA, and encouraging them to become increasingly emotionally attached to the email system.
- In the value establishment phase, the user needs to become familiarized with using the product, and to feel a sense of stability. In this period, more icons will have become larger and developed clearly discernable colors, and the user should come to feel a sense of accomplishment and satisfaction at having successfully built up stable KIZUNA with family and friends.
- In the value as tradition phase, it is necessary to inspire a sense of security in the user, that the user can continue to use the product to which he or she has become attached. In this stage, information on icons that have been nurtured in the product can be transferred to other devices, allowing the user to gain a sense of sescurity that human relationships can be sustained.

As the discussion above shows, the KIZUNA Visualizer encourages user communication, and makes possible the continuance and deepening of KIZUNA.

VI. CONCLUSION AND FUTURE WORKS

In this study, we developed an email system, the KIZUNA Visualizer, designed to sustain and deepen KIZUNA—namely the precious bonds that exist between people—in response to the increasing value placed on such bonds. During design development, we adopted the multi-time scale based on timaxis design, as well as bio-inspired self-organizing systems in order to adequately consider the changes undergone by KIZUNA over time. The results of our \study are shown below.

- We proposed the KIZUNA Visualizer, an email system that enables the visualization of the state of KIZUNA through icon changes corresponding to the number and frequency ofemails sent and received.
- We set up six functional algorithms related to icon changes, and used those to construct an email system that also takes into account the relationship of icon elements with each time scale. We then constructed a workable prototype of the system.
- We considered the usefulness of the KIZUNA Visualizer from the perspective of the value growth process. The functionality of the KIZUNA Visualizer is capable of expressing the state of icons, which correponds to those values required over the KIZUNA deepening process. The results of our study imply that this system can indeed function to maintain and deepen KIZUNA.

Going forward, we will need to use the prototype we have developed to conduct evaluation testing with multiple users, in order to validate the effectiveness of the KIZUNA Visualizer and make further improvements. This will allow us to continue our work in the maintenance and deepening of KIZUNA.

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