Sumi-Nagashi:
Creation of New Style Media Art with Haptic Digital Colors

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ABSTRACT

This installation provides painters with a method for feeling attributes of digital colors and a fluid canvas. When a user of this installation moves the stylus paintbrush over the digital canvas, he/she senses the "weight of the colors" through the brush. For example, the user experiences dark colors as heavy in weight and light colors as light in weight. Complex painting is expressed as a mixed tactile sensation using a new desk-style force feedback system called the "Proactive Desk." Other existing digital painting systems that use haptic cues usually aim to be physically and visually correct. In this approach, however, we invested effort in enhancing the relationship between digital colors as a virtual material and the sense of touch. Additionally, we took the importance of co-located drawing work space for creative tasks into account. We believe that this experience will arouse new inspiration and give digital painters the opportunity to experience again how important touch is for creativity in art.

Categories and Subject Descriptors

H.5.1 [**Information Interfaces and Presentation**]: Multimedia Information Systems – *Artificial, augmented, and virtual realities*; I.3.6 [**Computer Graphics**]: Methodology and Techniques – *Interaction techniques*; H.5.2 [**Information Interfaces and Presentation**]: User Interfaces – *Haptic I/O, Input devices and strategies*; I.3.4 [**Computer Graphics**]: Graphics Utilities – *Paint systems*; J.5 [**Computer Applications**]: Arts and Humanities.

General Terms

Algorithms, Human Factors, Theory.

Keywords

Haptic feedback, digital painting, media art, virtual reality.

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1. INTRODUCTION

The digital revolution has drastically changed the field of art. For those artists who prefer to use the most advanced technologies, the selection of computers as tools might be considered natural. Most of the artistic forms expressed by current computer technologies, however, involve only the senses of sight and sound. As a result, it has been difficult to incorporate into these artworks the important element of the artist's corporeality, which is required for the creative process.

The importance of corporeality in the field of art is well known by all artists, and they understand it intuitively. An attractive piece of art can be created by deeply understanding and interacting with the materials and tools through physical contact, and this is the starting point of creation. This involves tactile sensations on the skin, perceptions of very small changes in the muscles, and physiological changes in the brain activated by those feelings. Artists translate their feelings from those real elements into another dimension [4, 6, 18].

However, today's "Digital Artists" have had to sense those feelings unnaturally, using nontactile tools and digital materials having only visual properties, as if they were real tools and materials being actually touched by their hand and by their imagination. This means they have had to accomplish the same act of creation while using limited human sensations, unlike other classic artists who are able to fully use their resources. This may lead one to think that there is a limitation to multimedia creativity

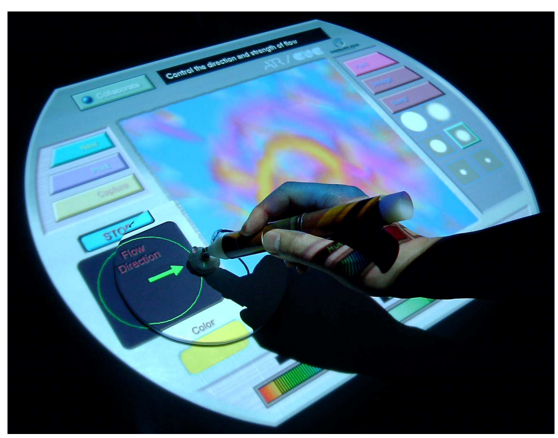

Figure 1. Installation "Sumi-Nagashi."

and no necessity for human nature in the field of digital or media art in comparison with other fields of art. However, it would be hasty to say that there is therefore no future in this field. On the contrary, there is great potential that we have never experienced still hidden in digital art; it is only in its infancy.

This paper describes one attempt to incorporate corporeality into the world of digital art, and to show the new artistic possibilities that are born from the harmonious integration of the senses of sight and touch through a new style of installation, "Sumi-Nagashi."

2. SUMI-NAGASHI

2.1 Concept

The purpose of this new art form is to add tactile sensations and corporeality to the world of digital painting. The installation "Sumi-Nagashi" allows painters (users) to experience a fluid pictorial installation, and to enjoy the process of creating a digital picture with visual and haptic sensations simultaneously. Figure 1 shows a scene of an interaction with the installation.

The traditional form of *sumi-nagashi*（墨流し）is an ancient Japanese artistic technique, which means literally "ink-floating." Japanese *sumi*-ink thrown onto a still water surface makes dynamic patterns by disturbing the water's surface, and the beauty of the constantly changing forms is captured instantaneously on Japanese paper. The origin of this art form is believed to be older than other similar techniques such as, for instance, European "marbling [9]."

There are many classic artworks which have water as their motif because of the physiological relationship between water and the body. The art form of *sumi-nagashi* incorporates dynamic changes in the patterns and additionally is an interactive creative process. This interactivity and dynamic change is closely related to modern digital and media art. This is why we chose Sumi-Nagashi as the motif and title for touchable digital painting.

The most creative point of this new art form is to enhance the experience and enjoyment of the digital painting process for the user to approach the level of real interactive art. This installation lets the user perceive corporeally the virtual attributes of the digital color, which is generally perceived visually from the picture, through the sense of touch via the force feedback brush and canvas. This will give all painters an opportunity to realize how important the sense of touch is in the creative art process.

In the application Sumi-Nagashi, the user is able to draw a picture naturally on a physical desk in a similar manner to conventional painting software. The desktop of the desk is actually a type of "digital canvas." A picture generated by the computer as a result of an interaction with the user is projected onto the desktop by an overhead projector. The user holds a device shaped like a paintbrush and moves the device directly across the desktop as though it were a real brush. The path of the brush is colored by digital paints and the image on the desktop changes according to this new color information in real-time.

Unlike conventional painting software, in addition to a "color layer," our canvas has a "streaming layer" defined by a virtual flow, so that the painted images change constantly, from moment to moment. The flows in various segments of the streaming layer change depending on the actions of the user, and that flow is reflected in the color of the color layer. When the user adds a new color to the canvas, that color is drawn into the virtual flow of the streaming layer. This color then mixes with the colors already on the canvas, creating a new picture that changes with each passing second. Figure 2 is an example illustrating this changing of the visual information.

As the digital canvas, we have used a new force feedback system, called the "Proactive Desk [10]," which was developed in house for displaying physical information represented by the sense of touch. In this system, a computer calculates the force resulting from the action of drawing, and the system provides the physical force along the surface of the table through a paintbrush-shaped device held by the user.

In this way the virtual flow defined by the streaming layer can be communicated to the user while drawing as the force of that flow,

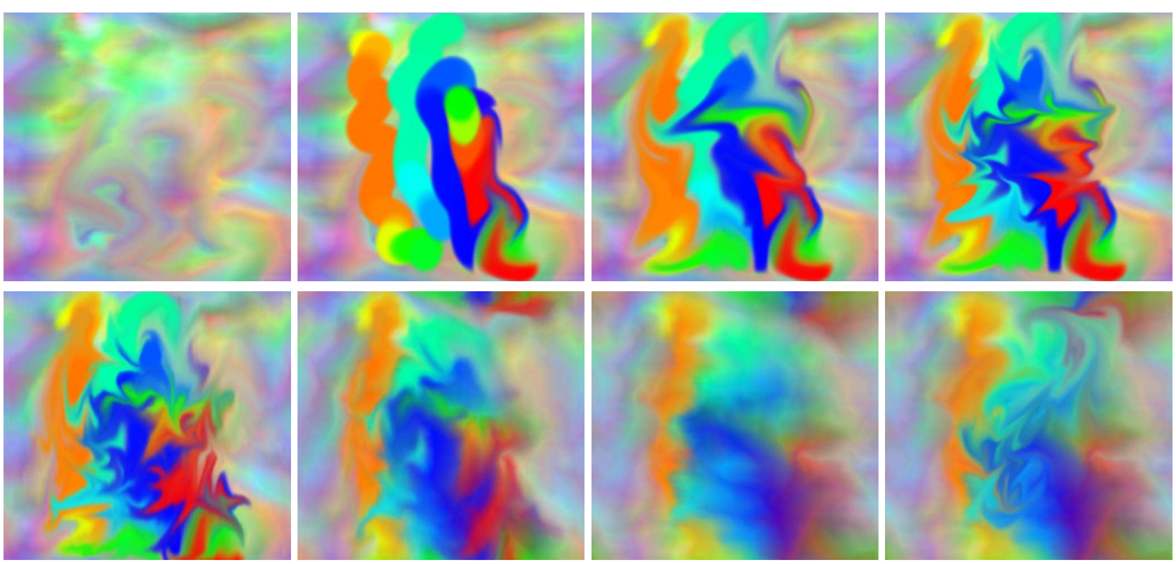

Figure 2. Creation of a new style media art using digital paints in a harmonization of the senses of vision and touch.

whose strength depends on the size of the brush and speed of the flow. Additionally, we also attribute the colors placed on the canvas with virtual "weights." For example, when psychologically perceived "color weights" are assigned as the attribute of the digital color, the user will sense "heavy" feeling from a dark color and "light" feeling from a light one. Furthermore, while the user places a new color on the canvas, he/she is able to sense the changes as a tactile sensation when a new color crosses the boundary of an existing color on the canvas, or when it passes through a darker color.

2.2 Related Works

Some commercial painting software, such as Painter [2], are commonly used as digital tools by many painters. In such software, the user uses a mouse or a graphic tablet to draw a picture while looking at the computer screen. And the tools, usually listed as icons for selecting functions, exist only as metaphors, which mimic actual painting processes. This mimicry is sometimes based on results of physical simulations of the relationship between real materials and tools. These simulations are generally constructed from models of materials, for example, paints as optical characteristics and canvases as textures, or from input data from devices such as drawing strokes and pressure levels of a pen. The result is then displayed onto a CRT or LCD monitor as visual information only. These digital tools have a lot of merits compared to real painting when making a picture. For example, easy and unlimited undoing or redoing action, many brush types, recreation from a digital carbon copy, and elaborate editing using region zooming, are all common. We think the main goal of conventional painting software is to attempt to be physically and visually correct. Although there is no feedback from the picture except visual attributes, it is enough to do tasks for making paintings.

Some approaches have been proposed for making haptically correct simulators for bringing tactile sensations into digital painting [1, 3, 15, 17]. Haptic feedback devices might have the power to overcome this limitation on the current human-machine interface. For example, DAB [1] is a kind of digital simulator of the real painting process based on computed models of the actual three-dimensional structures of brushes and canvas. The system uses the haptic feedback device PHANToM [15] as its input device instead of a mouse. This most famous commercial device has a stylus-shaped interface. It is able to trace the motion of the stylus in six degrees-of-freedom, and it is also able to generate forces of three degrees-of-freedom. The system obtains strokes of the stylus as input from the real world, and updates a virtual environment, such as a posture of the model of the brush. When contact between the model of the brush and canvas is detected, the system calculates an appropriate resisting power of the canvas based on the models. The result of the simulation is displayed on the visual monitor in front of the user and is returned to the user through the stylus as an output of tactile sensation. Therefore, the user is able to paint as if he/she is using an actual paintbrush and canvas in the digital world. FreeForm [15] is another digital simulator for sculpture using the same device. In this system, the user can sculpt a digital statue using digital engraving knives.

All the above applications are excellent digital simulators of real techniques for creating art, but they are just simulators. From the viewpoint of how much it is possible to stimulate painters' inspirations, there are few differences between those simulators and classic painting procedures using real materials.

The main purpose of our approach is not necessarily to develop a simulator which is mimicking the actual painting process, such as using an optical model of colors and a model of a real paintbrush and canvas. Instead, we consider it important to add real and virtual sensations, in which some attributes will be exaggerated and not existing in the real world, into the digital creation of artworks. We want to enable painters to recognize pleasure and meaning in the process of drawing pictures having corporeality.

Additionally, previous applications do not care so much about the problem of separated drawing and viewing work spaces, but concentrate primarily on being correct simulators visually and haptically. We think that the kind of special skill needed to understand that the motion of a pointer in the computer's display is related to the motion of a mouse existing at a distance from the pointer is hindering and unnecessary for the creative process. Therefore, only providing a digital interpretation of real painting, including real *sumi-nagashi*, is not sufficient; it is necessary to approach the art form from a novel expression that can only be accomplished by using new media.

Sumi-Nagashi, by using digital media and new hardware, gives painters a method for touching the virtual attributes of digital colors and a fluid canvas. Additionally, the art work interactively created by this tool will convey to audiences more strongly and directly the corporeality of the creator of the painting through the media. Traditional painting provides a very real experience, but the power of this experience is not drawn from the physical sense of touch alone. Other factors combine to make the overall experience one of creativity and joy. It is this, rather than the actual physically-correct reproduction of traditional painting, that we are attempting to capture.

3. APPLICATION

3.1 Virtual Feeling from Digital Colors

As shown in Figure 1, the user holds a Japanese-paintbrush-like device and adds colors onto the digital canvas. When the user is drawing, he/she will feel something from this digital world visually and corporally.

In this application, we took into account various factors to construct the relationship between color (visual sensations) and the sense of touch. The thing that we were most aware of when creating this relationship was the sensation of handling the virtual viscous paints, and then including: the disparities lying on the boundaries of color; the dimensional bump in the paints at the stage when they are drawn on the canvas; and both the visually and psychologically perceived weights.

This section first describes some functions for drawing which are related to the generation of visual sensations. Then we describe haptic rendering methods which are constructed from the relationship between visual rendering and the perception of color.

3.2 Visual Rendering

3.2.1 Color Layer: Drawing Functions

The drawing functions implemented in this installation work in the same way as in a general painting system. Three functions, "Paint," "Smudge" and "Stamp," described below, are the most basic tools affecting the "color layer" of the digital canvas. Those functions' icons are listed on the desktop and the user can switch the function freely by selecting the icon as if changing a paintbrush. Figure 3 shows a picture drawn using those basic functions.

"Paint" is the simplest function. When selecting this function and moving the brush, the currently selected color is placed on the color layer of the canvas continuously. Of course, the user can change the color and size of brush by using a color selector with sliders or thumbnails listed beside the canvas.

"Smudge" is a function for mixing and spreading colors already existing on the canvas. When the user selects this function and moves the brush, this acts like a copying function. At the first moving action of the brush, the system copies colors, *i.e.*, a texture, of an area under the brush into the memory. And while moving the brush, the system pastes the copied texture onto the current brush's location by applying a blending parameter, and updates the memorized texture to a texture of the current location. Figure 4 shows some results of this function. In this figure, the user moved brushes having four different parameter values in a downward stroke. The leftmost stroke is a result of the brush having a large diameter and low blending parameter. The second from the left is also a big brush but has a high blending parameter. The blending parameter is a mixing rate between the memorized texture and the texture on the canvas. In other words, the texture applied with a high blending parameter is attenuated more quickly than a low one. The third and last examples are the results of using smaller brushes.

Lastly, "Stamp" is a function to put characters on the canvas. When the user selects this function, thumbnails of characters appear to the side of the canvas, and then the user can add his/her favorite one by choosing from them.

3.2.2 Streaming Layer: A Floating Effect

The colors placed on the color layer are gradually carried away along the flows of the streaming layer when this function is enabled.

The streaming layer is expressed as a kind of two-dimensional vector field of the velocity of flow. In this implementation, we installed pre-rendered streaming data of a certain direction in the application to reduce computational cost. To avoid a monotonous visual effect, the prepared streaming data has small contrasts between the velocities and directions of each area to mimic the movement of running water. The global direction and speed of the stream are controlled by the user using a controller set beside the canvas. Technically, we will implement real-time fluid simulation and local control methods like making ripples from water drops and blowing on the water surface in future work.

The visual effect of carrying colors is calculated by the following equations,

$$C(t+\Delta t)[x,y] = C(t)[x - V'_x, y - V'_y] \tag{1}$$

$$\vec{V}' = M \cdot \vec{V}(t)[x,y] \tag{2}$$

where $C(t)[x, y]$ is a color at a time t on a coordinate $[x, y]$ on the canvas, $V(t)[x, y]$ is a two-dimensional vector expressing a flowing direction and speed at a time t on a coordinate $[x, y]$, M is a 2×2 transformation matrix for controlling the global direction of the stream including a rotating and scaling factor defined by the user's operation, and V'_x and V'_y means a component x and y of vector V', respectively.

Figure 5 shows colors floating on the virtual stream. Words written by the "Paint" function (left-hand image) are made to flow by the streaming layer as if they were melting (right-hand image).

3.3 Haptic Rendering

When the user moves the brush, he/she is able to perceive a changing of the tactile sensation through holding of the paintbrush-like device in addition to perceiving a visual change. Here, we modeled the physical haptic feeling from digital paints and canvas as a resultant force of three kinds of virtual force: inertia power, color friction, and flow resistance. Figure 6 illustrates this model.

3.3.1 Influence of Color "Weight"

First, we chose the general idea of "weight" of color for the most basic attribute of color, which is derived from a perceived impression of color. The impression of color is sort of subjective and it will be completely deferent for each person and their situation. For example, the painter will regard a white color as a heavy color because it has a high density of light. On the contrary from the viewer's side, light color in printed matter and movies will be perceived lightly because it is a color of background.

Figure 3. Picture drawn using basic painting functions.

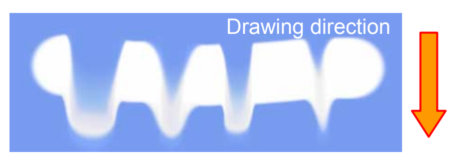

Figure 4. Effects using different "Smudge" brushes.

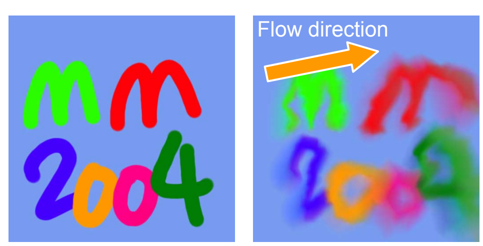

Figure 5. A melting image by influence of the streaming.

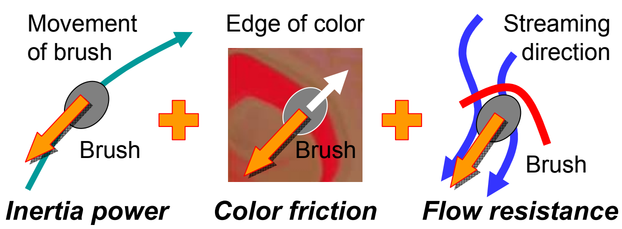

Figure 6. A model for haptic rendering.

Therefore, we prepared some mapping methods for binding "weight" to the digital paints, and let the user select among them. The following are the selectable parameters for mapping;

Saturation – This value differs depending on pigments of paints. And there is a possibility that its deference of material will affect a hardness of the stroke delicately.

Hue – This value mainly relates to categorizing colors, such as a warm color and a cold color. For example, to put importance toward the user's favorite color group, he/she will sense more feeling from that group.

Luminosity – This value relates to the psychological feeling of color more intuitively. Some people get a "heavy" feeling from dark colors, and "light" feeling from light ones.

The user can select which mapping method he/she uses and which level of high and low he/she assigns as "heavy." This means there are six choices as a mapping method. In the following description, we use luminosity and highest level of it is lightest as the mapping method as an example.

The luminosity of this mapping is actually calculated after it is converted to gray-scale. We used the following equation for setting the luminosity L from the RGB color system,

$$L = 0.299 \times R + 0.587 \times G + 0.114 \times B \qquad (3)$$

where R,G,B are the normalized levels of the red, green and blue components of color. This is well known as an equation for changing a video signal from RGB format to YUV format.

The user is able to feel the influence of the virtual weight strongly when he/she selects a color using the color selector and is drawing in "Paint" mode. We implemented this feeling by mimicking the "inertia power" simply as the following equation,

$$F_{inertia} = -m \cdot \vec{a} \qquad (4)$$

$$m = f_i(L, S) = c_l \cdot (1 - L) + c_s \cdot S \qquad (5)$$

where a is an acceleration calculated from movement of the brush, S is a variable in relation to the size of brush, and f_i is a function changing linearly according to L and S. An example of m is shown in equation 5 using constants c_l and c_s.

When the color is changed using the color selector, the weight of the color is changed and it affects inertia power, which the user feels simultaneously.

When selecting the "Smudge" or "Stamp" function, the definition of m is slightly different from the above equation. In the "Smudge" mode, L is calculated from all values of luminosity in the memorized texture, and in the "Stamp" mode, L is an average luminosity of the selected character.

3.3.2 Influence of Underlying Colors

The "color friction" gives the user a kind of feeling of the textures on the canvas, which depends on contrast and change of colors. For example, the user will feel more friction from a striped area and perceive an edge at the boundary of colors by feeling resistance there. This force is represented as the following by using a parameter R, which means a mixing level of the colors in a target area.

$$F_{friction} = -c_c \cdot R \cdot \vec{d} \qquad (6)$$

where c_c is a constant, and d is a normalized traveling direction of the brush.

R changes according to the "weight" of colors (defined above) lying under the brush. We determine R from the standard deviation calculated by sampling some colors' weights lying along the traveling direction of the brush. The value of the standard deviation of the sampled colors rises when the area being approached by the brush has a high contrast such as at color borders in a striped pattern. Conversely, an area with a low contrast, such as flat colors or similar colors, reduces the value of the standard deviation. Therefore, this works as a kind of friction depending on the colors on the canvas.

When the condition of the color layer is changed by the user's painting action, the power of the "color friction" is changed dynamically. For example, when the user spreads colors by using the "Smudge" function, he/she will get an impression of smoothness from the visual and tactile sensations simultaneously.

3.3.3 Influence of Streaming of Virtual Water

Dynamic changes derived from the fluid canvas are one of the most novel points of this application. Here, we attempt to set another tactile sensation as a virtual property of this digital painting system.

The "flow resistance" is defined as the resisting power of the brush against the virtual water's stream. The direction and strength of the stream is defined as a kind of an average of the summation of the velocity vectors of the streaming data in the area touching the brush. The force of flow resistance is calculated as a product of the average vector and the size of the area expressed by,

$$F_{flow} = c_f \cdot S \cdot f_f(\vec{V}') \qquad (7)$$

where c_f is a constant, S is a variable in relation to the size of brush, and f_f is a weighting function expressed by,

$$f_f(\vec{V}') = \sum_{x,y}^{area} w[x,y] \cdot \vec{V}'[x,y] \qquad (8)$$

$$\sum_{x,y}^{area} w[x,y] = 1 \qquad (9)$$

where $w[x, y]$ are defined as variables for decreasing influence depending on the distance from the center of the brush.

By this equation, the streaming of virtual water pushes the user's paintbrush-like device along the direction of the flow.

3.3.4 *Resultant Force*

Finally, a resultant force rendered by the haptic feedback system is expressed as the following summation,

$$F_{total} = w_1 \cdot F_{inertia} + w_2 \cdot F_{friction} + w_3 \cdot F_{flow} \quad (10)$$

where w_1, w_2, w_3 are weighting parameters for determining the contributing ratio.

From this equation, we understand that a large force will be generated when: a "heavy" color is selected; rapid movement of the brush occurs; the brush crosses a high contrast area and the edge of the colors; and the brush runs quickly with streaming (see Figure 6.)

4. HARDWARE

4.1 Proactive Desk

The Proactive Desk, shown in Figure 7, is a system for generating physical forces and for interacting with the digital world directly and intuitively [10].

It has the shape of an ordinary desk and is an expansion of the Digital Desk [16]. In the original concept of Digital Desk, objects on the desk such as a notebook being written on and motions of a user's hands are captured and tracked by sensing devices such as a camera and a position sensor, and the information is digitalized, analyzed and used as input to the digital world. Then, the computed results in the digital world are returned as an image projected onto the desk of the real world from an overhead projector.

The Digital Desk broke through the boundaries between the digital world of the personal computer's desktop and the physical world. The desktop works by capturing information about the physical world. For example, the user can point to icons with his/her own hands directly without using a mouse or trackball, and the system imports the physical object's properties (shape, size, weight, color, number, text and so on) and uses them as the digital object's properties. However, this system provides the user with only visual feedback in the form of a projected image on a common physical desk. Accordingly, the direction of the physical feedback is limited to that from the physical world to the digital desktop, although the visual feedback loop is closed. The Proactive Desk adds an output channel for physical information in this interaction cycle (Figure 8.)

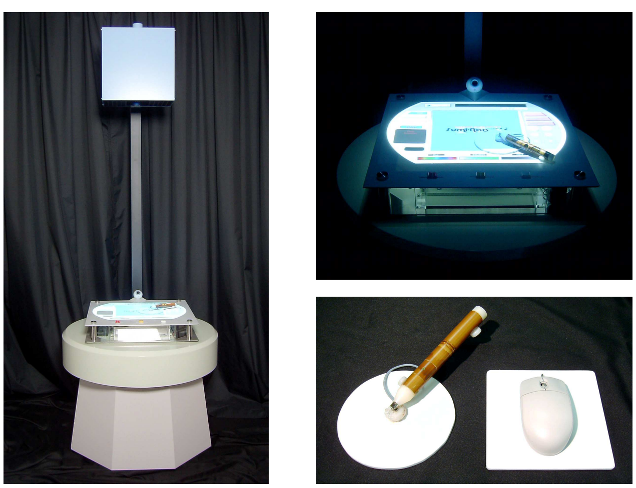

Figure 7. The Proactive Desk.

Left: *overview,* ***Upper-right:*** *application running,* ***Lower-right:*** *paintbrush-like I/O device and mouse-compatible device.*

4.2 Mechanism of Force Feedback

A linear induction motor (LIM) is employed as the mechanism for generating the physical information. Figure 9 illustrates the basic mechanism of a one-degree-of-freedom LIM. The Proactive Desk uses two sets of LIM cores and coils placed in orthogonal orientation inside the desk. The two-degree-of-freedom LIM moves a nonmagnetic conductive material plate (we call it a "Forcer") on the desk in any direction in two-dimensional space in accordance with Fleming's left-hand rule [11]. The maximum force generated on the Forcer depends on the size and thickness of the plate. The trial system designed for this installation has generated maximum forces of 11 N using a copper plate of 200 mm × 100 mm × 10 mm [10]. For this installation, we chose a circle-shaped aluminum plate of 150 mm in diameter and 5 mm in thickness as the Forcer for effective handling, and it can generate about 5 N maximum. The plate was colored white, the same color as the screen, so it disappears from the user's sight during projection (see lower-right picture of Figure 7.)

Additionally, the system tracks the Forcer on the desk and controls its position using feedback procedures for making it an input and output device. An LED attached on the Forcer is traced by position sensitive detectors (PSD) placed overhead. The computer calculates appropriate powers using this location data to

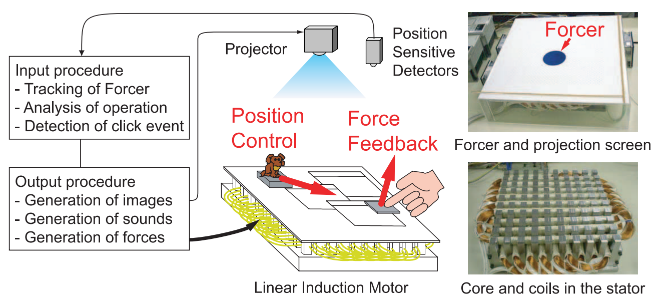

Figure 8. Configuration of the hardware.

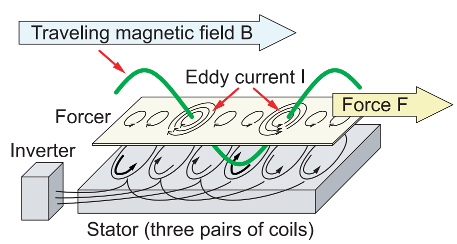

Figure 9. Mechanism for generating physical forces of a linear induction motor.

The principle of one-degree-of-freedom linear induction motor (LIM) is the same as that of a widely used standard AC three-phase rotary motor. In the stator, three pairs of coil sets are lined up along the moving direction. When a three-phase current is turned on for each coil set, the traveling magnetic field ***B*** *is generated along the coils. Avoiding the field, the eddy current* ***I*** *is induced on the forcer, and the current* ***I*** *and the magnetic field* ***B*** *generate the translational force* ***F*** *on the forcer by Fleming's left-hand rule.*

move the Forcer toward any location and to give the user tactile sensations. In this system, we used an infrared LED to avoid the influence of mixing illuminating colors because the computed image is projected on the same desktop. We added a filter to remove infrared light from the lens of the projector, and also place a filter in front of the PSD through which only an infrared ray can penetrate.

The Forcer also has a grip on the plate to make it the input and output interface of the system. In this application, we used a paintbrush-type grip to mimic real drawing tools. Additionally, the grip has a button for the drawing operation (We are planning in future work to change this button-type operation to another method, such as using a pressure sensor, for more intuitiveness.) When the button is pressed and released, the LED on the Forcer flashes with unique pulse-patterns for a few milliseconds (a battery and a microcontroller for driving the LED are installed inside the grip). The PSD is an analogue device having a potential running power in the order of kHz, which is adequate for detecting those patterns. Then this detection becomes a trigger to perform the clicking operation of the mouse. While the button is being pressed and the device moved, a color is put on the canvas, and then the user can feel appropriate physical power from the digital color by handling the Forcer.

4.3 Advantages

The Proactive Desk is a solution for building a closed physical feedback loop within the concept of the Digital Desk. This system enables the user to handle objects with the feeling of haptic sensation as if he/she were handling real objects, and it can also control real objects on the desk in response to events on the digital desktop.

Many haptic feedback devices have been proposed for various applications [5]. An appropriate device for a drawing application is a sort of force feedback system which is able to generate at least two dimensional forces. One of the advantages of the Proactive Desk is the LIM offers the advantage that the force to the Forcer can be easily controlled and a more powerful force can be generated directly in a large area than by an electromagnet-type force feedback device using the suction force of the magnet. For example, the “actuated workbench [12]” is a system using an array of electromagnets as a mechanism for generating haptic sensations. This kind of system needs to take care to avoid a “Manhattan motion” in which an object just moves along the axis of the X-Y plane in a step-by-step, zigzag movements, like the blocks of a large city. Also, this type of system hardware configuration tends to become more complicated the greater the size of the array.

Additionally, the large mechanism that produces the forces of the Proactive Desk is completely concealed underneath the canvas. This means that the user is able to operate the system’s paintbrush-like device in a way that seems like drawing on a normal tablet. No mechanical link structures or strings, which is sometimes used as a key mechanism for force feedback and posture control of input-output interface in other devices [5, 13, 14, 15], disturb the projection of the desktop image. Consequently, this system is more reasonable for the operation of a digital desk requiring two-dimensional tasks than other force feedback devices. These advantages are suitable for the creation of our new style digital painting art form.

5. DISCUSSION

When considering painted artworks, many people tend to focus on aspects of visual expression for artistic meaning, relying on the colors, shapes or figures of the painting. Intrinsic to paintings, however, is color information structurally comprised of *matieres* (materials, textures), which are created through the use of well-considered and appropriate techniques selected for the unique characteristics of the media such as painting tools and materials. The expressive forms of these characteristics are formed from the stimulation of all of our physical senses. The most important element of all artistic expression is the relationship with our bodies. When both the artist and the viewer gain an awareness of this physicality through the artworks as media, then it becomes possible to gain a sense of reality, and to build a personal and definitive relationship with that physical form. This is how the value of the piece as a work of art originates.

Digital technologies have made it possible to freely handle materials with different physical characteristics within a single methodology. This is one of the most significant factors in the current so-called “digital revolution.” At the same time, however, we might have left something behind; the issue of “corporeality,” which is essential to the relationship between people and art. Or it perhaps means we were previously only able to seek media outside of our bodies through the curse of “visual sensations” lacking this corporeality. At times, it appears that the people involved in the field of media art and digital art consider this lack of corporeality to be a superiority and to define the worth of these new art forms. We believe that this is simply a misunderstanding, however, which has resulted from the fact that this field is still very new, and that both the hardware and the software have yet to mature.

Ideally, all of our physiological and physical sensors must be excited actively by an artwork. Even so, it may not be necessary to give physical stimulation to all of these sensors. A minimum of physical information is enough to activate a large area of the brain. The sense of sight and the sense of touch offer the most efficient forms of information that can be controlled by modern computer technologies.

Kurumisawa’s art works of “Image to Touch [7]” and “Non-Material Construction #1 [8]” at the SIGGRAPH Art Gallery in 1998 and 1999 were previous attempts to bring tactile sensation to real painting. The purpose of a series of his works was to lead a tactile sensation optically from a visual sensation through his digital paintings and a special printing technique. We can say that the installation Sumi-Nagashi surpasses the “Image to Touch” with an advanced system and concept.

Sumi-Nagashi makes it possible for the painter to gain an awareness of the exact relationship between the painter and the installation at the very moment of that experience through both eyes and body, through both visual and tactile sensations. This relationship cannot possibly be perceived simply by looking at the visual phenomena that occur in the Sumi-Nagashi. This is nothing less than a true example of the presentation of actual sensory experiences in which the user’s body itself becomes a medium. The media begin and end with the individual.

In this implementation, we invested effort in constructing the relationship between digital colors and the sense of touch. Of course, these are only virtual meanings. We understand that to use just the laws of the real world in their original form would lead to a lack of appeal and creativity in this type of artwork.

By actively attaching meaning to colors, which just exist simply as luminosity information, physiological meaning is added to this digital data of color and the data is then converted into physical meaning. The perceived persuasiveness of the digital colors output from this installation provides a strange and wonderful experience for the user. Meaning can be easily understood if the user is an artist. The physical communication with the motif, which is the visual and tactile sensations experienced by the artist through the process of producing the artwork, provides an important element of persuasiveness to enable the artist to recognize the work as a "work of art."

The hardware of the Proactive Desk communicates these sensations to the user clearly and convincingly. In this sense, it would be impossible to understand this artwork wholly without touching it directly.

One might think that the work presented here falls into the category of media art. However, has there ever been an example of media art or digital art that could not be understood without experiencing it directly? Doesn't awareness that information can be communicated without personal experience because it is media detract from the value of the media? The "sense of sight and the sense of touch" are equated with "software and hardware." The beauty created through the delicate relationship between the two has created a strange and wonderful moment that can only be realized through direct experience. In this sense, it is in just such a moment that Sumi-Nagashi becomes a true work of art.

6. CONCLUSION

This Sumi-Nagashi is designed to bring corporeality into the field of digital art. Our ultimate goal in creating this system is to expand upon a kind of corporeality that can only be achieved through digital technologies. This means attaining the same level of experience as that in which a painter accurately grasps the viscosity of paints and the adhesion of the paints to the canvas through a delicate sense of touch, gradually building up to the desired expression. We have to expand the range of realistic perceptions through studies of the corporeality of artistic works and the relationship between the sense of vision and the physiological mechanism of the brain.

This installation is not an example of just applying haptic information to digital painting. We will expand this art form in future works. For example, if the Proactive Desk can remember, store, and represent the actions of people, it can become a machine to share or experience someone's feelings beyond time and space through digital media. Additionally, we mainly treated the relationship between visual and haptic cues in this implementation, because tactile sensation brings from visual sensation a new understanding of the importance of touch in the interaction between the materials and the body. However, adding audio sensation as a virtual attribute is also interesting. For example, people might sense some kind of impressions from sounds such as "heaviness" or "complexity." New creations might be born by constructing a mapping method of these. We want to sense harmonized feelings of visuals, audio, and hapics in future work.

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