A Virtual and Interactive Light-Art-Like Representation of Human Silhouette

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***Abstract*—Light art represents various objects by a light stroke drawn in the air. It takes about 10 to 30 seconds to create a light art picture. We could create a light art movie by binding a set of pictures; however, it is a time-consuming task because we need a large number of frames to create a movie and difficult because a person would need to author a sequence of temporally consistent frames. To solve this problem, we are developing a virtual and interactive light-art-like system. This system extracts edges of human bodies from depth information and then applies a point-to-curve algorithm to mimic hand-drawn figures. Finally, the system applies neon-like drawing and a visual effect on the figures and displays them in real-time. This paper also introduces our artwork produced with this system, and a user evaluation that shows that the artwork conveyed happiness and excitement to the audience.**

***Keywords*-Light art; human silhouette; point-to-curve algorithm;**

I. Introduction

Interactive art has been actively developing alongside computer technology. It aims to allow people to participate and enjoy using digital mechanism and artistic representations. Light art is created by capturing light strokes drawn in the air while the camera shutter is held open for an extended period. Creating a light art movie would require substantial time because it would need a large number of light art photos, each being time consuming to produce. To address this challenge, we are developing a virtual and interactive light-art-like system.

The system operates by first extracting edges in real time by using pixel depth values of human silhouettes. Second, it converts the edges to sequences of points and approximates the edges with Catmull-Rom spline curves. Finally, the system applies a neon-like rendering and visual effects to generate a light-art-like representation of the edges. Even though various types of research and products for interactive art have been presented, our system demonstrates a new representation by using human recognition and deformation techniques to simulate hand drawing. By intentionally losing the detailed appearance of the humans, we can anonymously represent shapes and their behavior. This feature is useful while developing various applications with this system.

We created an interactive artwork using this system. The artwork displays a person in front of this system as light art, as well as displaying a background scene of walking humans as light art. The background scene blurs, and the number of walking persons reduces when the person is interacting with this artwork. This piece was inspired by a photograph which represents the loneliness of a person in a crowded urban scene. We conducted a user evaluation where participants experienced this interactive artwork; unexpectedly, we found that many participants felt happiness and exciting because this form of artwork was new for them.

II. Related Work

A. Video expression with human silhouettes

There have been several interactive video artworks focusing on abstract human representation. Graphic Shadow [1] displays human silhouettes, and Collective Body3 [2] represents human bodies with a large number of particles. With a similar representation, Apple created an advertisement movie for iPod in 2003, which represents a human silhouette, background, and an iPod in only three colors. This movie does not represent a hand silhouette, which is overlapped with the body. Instead, it displays an iPod to associate the hand position. In contrast, our system draws human body parts as edges even when they are overlapped.

B. Hand-drawing-mimicking deformation

Zainab et al. [3] presented a technique for automatic generation of a hand-drawing-mimicking deformation sketch. This system applies a mathematical model presented by Flash et al. [4], which simulates arm movements on a plane, and generates hand-drawing-mimicking lines from the starting to the end nodes. However, it does not feature hand-drawing-mimicking deformation sketch from curved input lines.

Fernando et al. [5] presented a system which automatically generates continuous line illustrations by using graph theory and image processing algorithms. We suppose that applying Flash's system and Fernando's system on our system would be able to realize the drawing hand-drawing-mimicking human silhouettes deformed from the original silhouette recognized from a depth image.

Curtis [6] presented a technique to generate hand-drawn animations from 3D models which apply vector fields and particle models. However, this technique was not suitable for interactive systems because it required large computation times. Haller et al. [7] accelerated Curtis's technique so that we can apply to real-time systems. Remaining problems of this technique include that flickering may occur because it mimics hand-drawn strokes independently, frame-by-frame.

Our implementation applies a technique proposed by Wood et al. [8] which realizes sketch-like rendering for information visualization. This technique does not implement physical models of hand-drawing by a human but displays sufficient quality strokes to mimic light art.

III. Technical Components

This section describes the details of the technical components of our light-art-line representation.

A. Overview

Our system consists of the following steps.

1) Edge extraction using pixel depth values
2) Pixel-to-curve transformation
3) Neon-like drawing
4) Visual effect calculation

The following sections describe these steps. Our implementation currently applies human silhouette recognition using the Xbox One Kinect sensor by Microsoft.

B. Edge extraction using pixel depth values

This system extracts edges of the human silhouette from pixel depth values obtained by the depth sensor of Kinect. The depth values obtained by Kinect is in 13 bits; the system converts them to 8 bits to form a grayscale image. We can extract the edges from the human silhouette in the grayscale image. Here, we normalize the depth values so that we can easily distinguish the overlapped parts, by using the maximum and minimum values among the pixels inside human silhouettes. We calculate the normalized depth value $d_{nor}(x, y)$ by the following equation, where $DepthMax$ and $DepthMin$ are the maximum and the minimum depth values inside the human silhouettes.

$$d_{nor} = \frac{255 \times D(x, y)}{DepthMax - DepthMin} \quad (1)$$

Figure 1(Left) shows a grayscale image after normalizing the depth values. Figure 1(Right) shows a result of extracting edges from the grayscale image. We can extract hand edges overlapped with the body. Our implementation extracted edges applying Canny's method featured by OpenCV library.

C. Point-to-curve transformation

The system converts the edges consisting of pixels (called "edge pixels" in this section) to Catmull-Rom Spline curves for smoother visual representation. This process first selects a set of edge pixels which forms thin edges. For each edge pixel, the process traverses at most eight adjacent pixels and counts the number of edge pixels. This process traverses adjacent pixels again in the clockwise order starting from the opposite side of the selected pixels, and selects the first while pixel to remain. This traversal is then applied to the last selected pixel. Repeating this process, the system generates thin edges consisting of the remaining edge pixels. The system then selects a limited number of remaining pixels with constant intervals (every ten pixels in our implementation), and finally connects the remaining pixels by Catmull-Rom Spline curves.

Figure 1. Edge extraction. (Left) Grayscale image before edge extraction. (Right) Result.

D. Neon-like drawing

Light-art may look like neon tubes because it uses a light source to draw. Therefore, we apply neon-like drawing. Neon tubes are widely used as neon-signs [1] mainly in the downtown area. Usually, brightness will be high, and saturation will be low in the inner side of the neon tubes. On the contrary, brightness will be low, and saturation will be high on the outer side.

Based on the above, we developed a neon-like drawing method. On our system, we control the brightness and the saturation in HSV color space to specify the color of the inner side and the outer side of the neon line. For example, if we want to draw an edge like a red neon tube indicated by Figure 2(a), the system assigns a color while preserving high saturation and lowers the brightness for the outside as shown in Figure 2(b), and the brightness high and lower the saturation for the inside as shown in Figure 2(c). Figure 2(d) is an example of the neon-like drawing. Here, we apply a Gaussian filter on the outside to represent blurred neon tubes.

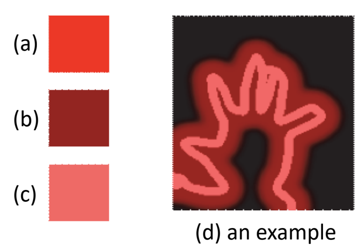

Figure 2. An example of neon-like drawing.

[1] http://www.sign-artcraft.com/neon.htm

E. Visual effect

We implemented several visual effects including after-image replications to arrange the light-art-like representation more impressively. To generate a new frame X', first we save the latest n frames just before the current frame. Second, we lower the brightness of each RGB on each frame. Finally, we take logical OR operation with the n frames. Our implementation calculates the pixel value as $\sum C_i P_i$, where P_i is the pixel value at the i frame before X. C_i will satisfy $C_0 = i$, $C_i < C_i - 1$.

F. Examples

Figure 3(Left) shows an example displayed by this system. It represents the human silhouette only in two colors corresponding to background and edges. Edges of human body parts are properly extracted even if they overlap other body parts. Besides, neon-like drawing makes the light-art-like color effect more realistic. Figure 3(Right) shows another example applying the after-image effect. This effect makes it easier to understand movement, even while looking at still images displayed by this system. We observed that users tended to make bigger gestures while looking at the display that is applying the after-image effect.

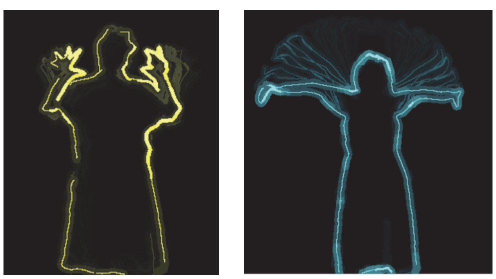

Figure 3. Examples after the visual effect.

IV. Interactive Artistic Work

We created an interactive artwork since we have enabled interactive representation of virtual light-art-like human silhouettes. This work was inspired by the photograph shown in 4, which is taken while adjusting shutter speeds [2]. The photograph emphasizes the human standing at the center by focusing on him while other people are quickly moving. We wanted to represent the loneliness such as experienced by the person in this photograph [3] in our work.

A. Overview

Figure 5 illustrates how to exhibit the presented work. In addition to the interactive human silhouettes represented by our system, the work displays the background scene and persons walking in the scene which are also retouched line light-arts. We implemented an interactive mechanism

Figure 4. (Left) A photograph taken while adjusting shutter speeds. (Right) Original picture of the background image used in this work.

whereby the feel of the background scene changes according to the change of distance between Kinect and the human playing with this work.

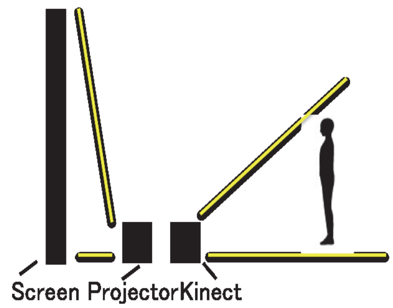

Figure 5. How to exhibit this work.

1) Light-art-like drawing of the background scene: The work first extracts edges from the background image. Figure 4(Right) shows an example of the background scene. Here, the work applies several (10 in our current implementation) types of blurred background images by using the Gaussian filter and extracts edges from each of the blurred images. Figure 6 shows examples of edges extracted from strongly or weakly blurred images. The work selects one of the sets of extracted edges for display, based on the distance between Kinect and the human playing with it.

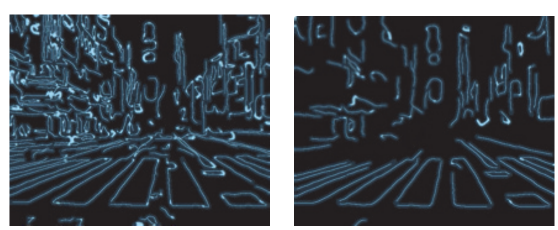

Figure 6. Blurred background image. (Left) Weakly blurred image used when a person stands near Kinect. (Right) Strongly blurred image used when a person stands far from Kinect.

2) Light-art-like representation of background persons: We also recorded people walking along the background scene. Here, we first recorded the walk of people as movie

[2] http://williamlulow.com/blog/creative-use-of-shutter-speed/
[3] http://picturesfromataxi.blogspot.jp/

files, one-by-one, then applied our technique to represent them as light-art, and finally synthesized all the people into a single movie file.

3) Painting of human silhouette: The work displays the silhouette of the person standing in front of the Kinect as light-art. Here, we paint the inside of the human silhouette in black to avoid that background scene being drawn inside the human silhouette.

B. Example

Figure 7 shows an example of the rendering results produced by the system. The background scene is clearly drawn when the person is close to Kinect, while the intensity and the number of background people increase. Meanwhile, the rendering of the background scene gets rough when the person is far from Kinect, while the intensity and the number of background people decrease.

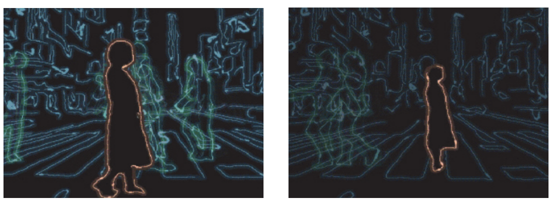

Figure 7. Example of the rendering results by the presented work. (Left) A person stands near Kinect. (Right) A person stands far from Kinect.

C. Subjective evaluation

We conducted a subjective evaluation of the work. Participants consisted of 22 university students majoring in Design. We explained to participants that the work is an interactive system which represents humans and background scenes as light-art, without telling them that the work was inspired from the photograph of a lonely person.

We asked their impression of the work after experiencing or observing. They rated the work in terms of: happiness, loneliness, sadness, excitement, and bewilderment using five-point Likert scales.

Considering the positive end of the Likert scale, 17 participants rated the experience 4 or 5 for happiness; this number was 5 for loneliness, 3 for sadness, 20 for excitement and 3 for bewilderment. The result that many participants experienced happiness and excitement was unexpected because we aimed to represent loneliness. Many participants who supported happiness and excitement mentioned that ”it is new” or ”interactive work is fun.” We suppose that the above are the main reasons why they felt happiness and excitement from this work. Meanwhile, some other participants mentioned that they felt loneliness because they were alone in a dark and wide scene.

V. Conclusions and Future Work

We have presented an interactive system which represents light-art-like images of human silhouettes in real time. This system recognizes human bodies and extracts edges of human silhouettes in real time. It also applies neon-like drawing and after-image effects to improve the richness of the visual presentation. We also created an interactive artwork applying this system and conducted a user evaluation. We concluded that the system is suitable for the creation of happy or exciting interactive works.

As a technical future issue, we would like to make the curves representing human silhouettes be more like hand-drawn shapes. As another issue, we would like to apply various other visual effects.

As another future work from the viewpoint of expression, we would like to create another work aimed to create happy or exciting stories. We expect that we are able to impress participants more by creating works based on such happy or exciting stories.

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