2D Tangible Code for the Social Enhancement of Media Space

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Abstract
In this paper we propose a two-dimensional tangible code and rendering method to enhance the user experience in social media spaces. The proposed media can be shared and physically experienced through current social network platforms such as microblogs because the proposed code follows the ordinary image formats. In terms of a physical representation of the proposed media, we utilized haptic feedback as an output modality. With the proposed conversion algorithm, haptic information in a Cartesian coordinate system is directly calculated from the proposed images. As a work in progress, sensory substitution with vibrotactile feedback is described.

Keywords
Tangible code, social interaction, sharing experience

ACM Classification Keywords
H.5.2 [Information Interfaces and Presentation]: User Interfaces-Haptic I/O.

General Terms
Algorithms, Design

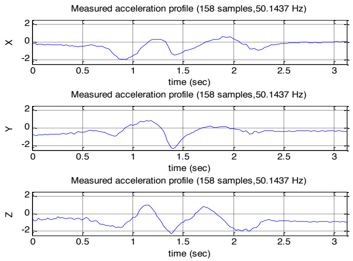

Figure 1. An example of captured motion data (3-axis acceleration)

Figure 2. An example QR code that contains all of the logged gesture data (upper) and URL information (bottom)

Introduction

Among the many types of media, people interact with 2D images such as photos or paintings as part of their common computing activities. In terms of interpersonal communication in an HCI context, images have played a significant role in enhancing the social experience in media spaces, as reported in previous research [6]. Microblogs such as *Twitter*, the use of which has exploded recently, also utilize these types of images to augment the text-based experience. In fact, many people tend to upload photos or drawings to social network services (SNSs) for a better description of a specific event or to relate a story [8]. In this way, the SNS environment further facilitates connectedness among people who are otherwise separated by physical distances along with emotional exchanges with multimedia support. However, it is important to reconsider that why the *practical* modality or form of information used for describing a personal experience continues to be photo-based visual information. In this context, we propose two image types in conjunction with a physical rendering method that can provide a user with an enhanced tangible experience under the current SNS framework.

Proposed media

What are gestures for?

The use of gesture data in an HCI context is mainly based on its functionality for issuing commands. Many practical systems, such as game consoles and remote controls have actively adopted gestural input methods. However, it is true that the use of gestural information is often focused only on its functionality and not on meaning *per se*. In terms of the implied meaning of a gesture, the modality has recently started to be used to describe and log the current status of people, as the gesture data can contain a hidden vocabulary of human day-to-day activities [5]. Considering a previous study [9], which reported that simple text-based personal messages can be saved and even considered as a gift, we assume that gestural information also can be utilized as a valuable personal medium; it can be created and experienced even in fairly meaningless contexts regardless of its functionality. From this perspective, two image types that can incorporate gesture information are proposed here.

System and data description

The proposed type of media comprises two types of 2D-code that store gesture data, i.e., a 3-DoF acceleration profile, in the form of an ordinary 2D image. For the gesture-capturing process, a commercial hand-held device, an Apple iPod touch™ was utilized. The sampling frequency used in this work was set to 50 Hz, which is sufficient to capture motion [11]. 14 paired subjects in groups of two participated in this experiment. Similar to microblog updates, the subjects were instructed to create 5 brief status updates based on both text and gestures. The gesture that should be logged for each session was defined as 'short motion' that can further explain or augment the corresponding text message. To preserve or not to distort the social context, each of the 7 subject groups (= 14/2) was comprised of two people who had a close relationship. During the entire session, the subjects could freely talk with their partner to maintain a relational context. However, they were visually separated so as not to affect or bias each other when creating the motion. The intention of the visual separation was to help the subjects to create a unique motion without their partner watching, which may influence the motion activity. For similar reasons, the experimenter was also

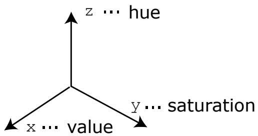

Figure 3. The gesture-color mapping rule.

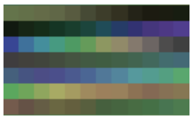

Figure 4. The cropped corresponding gesture image. Every pixel is represented in the form of square block.

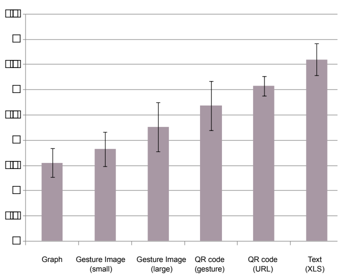

Figure 5. The mean rank of media preference. A smaller value denotes stronger user preference. Error bars represent the 95% confidence interval.

visually separated from the individuals in the groups. The measured average sampling frequency of the experiment was 49.95 Hz and the measured number of samples was 233 on average, which is approximately 4.66 sec and its 95% confidence interval is (4.40,4.93).

Proposed media

Considering that media compatibility is an important issue that affects the acceptability of a practical system, we selected the common image formats, i.e., jpg, and png, as the proposed medium platform.

- Type 1 - Gesture-based QR code

The QR code is used widely in many practical fields. The recent explosive use of hand-held devices has further increased the application area of this code. In this section, a type of QR code that can contain gesture information is proposed. The objective of the proposed gesture-based QR code is to allow general users to share their personal experience, which can be represented by gesturing, in the form of the familiar medium of a 2D image. For lossless data compression, Huffman coding, a well-known entropy-encoding algorithm, was applied before the QR code was created due to the limited capacity. After the process of entropy coding, the gesture data described in Figure 1 was compressed by 42.45%. Figure 2 illustrates examples of the proposed gesture-based QR code. Because the dense QR code could hinder one of the original purposes of the QR code, *legibility*, a type of hypermedia that only includes a URL that anchors a web page that contains the original XML data of the acceleration profiles was also proposed.

- Type 2 - RGB or HSV gesture image

The second proposed image is based on color bytes with the sequential three-axis acceleration data of the motion as shown in Figure 3. The equation below shows the mapping algorithm.

$$c_{i,j} = f(v_{i,j}), 0 \le i \le 2 \qquad (1)$$

Here, $v_{i,j}$ is the jth measured acceleration data of ith axis from the mobile device, and $c_{i,j}$ is the color byte of the jth pixel block.

The gesture image resembles abstract art, as shown in Figure 4. It was proposed based on the fact that a personal message can be even considered as a valuable gift [10]. In other words, the image is intended to enhance the implicit affective awareness, as addressed in previous research [6], as not as an explicit means of message transfer. With a given sampling frequency, the proposed gesture image can be translated into or can reconstruct the original motion dataset.

- Evaluation on user preference

After conducting the content creation process, each group member was instructed to experience the motion-based text data of their partner visually. The data is displayed in the form of a familiar microblog, i.e., *Twitter*. The data is displayed in the form of a familiar microblog, i.e., *Twitter*. The web page, which displays the collected motion data, was anchored to the text updates in the form of a URL. External links are widely used for photos, video, and location sharing in many microblogs. As questionnaire elements, a set of media types that included an explicit graph, small and large gesture images, the gesture and the URL QR code

Figure 6. Physically enhanced SNS. The motion that can be shared over the SNS can be visually experienced by the interested parties. If a haptic system is available, the media is then rendered kinesthetically to enhance the social experience. This mediated communication has advantages in that it can transmit touch information, which results in provoking an emotion, even repetitively.

Because the proposed gesture image is compatible with an ordinary image, it can be shared through current SNSs and transferred using RSS for implicit interpersonal communication.

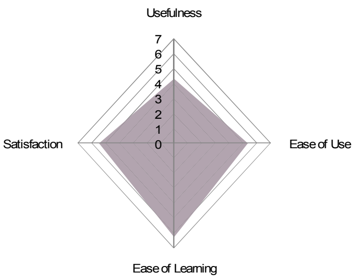

Figure 7. Result of the Usefulness, Satisfaction, and Ease of Use (USE) Questionnaire

and numeric text data were represented. A Friedman test revealed that there was significant differences in the ratings among the media types ($p < 0.001$, $\chi^2 = 59.4$, $df = 5$). The grouped media type also showed significant differences in the ratings ($p < 0.001$, $\chi^2 = 66.33$, $df = 3$). The subjects reported that they preferred the gestural image to the proposed QR codes mainly due to the appearance of media, as far as both types of media were intended to provide a system with gestural data. According to a preliminary self-reported test using the USE questionnaire [7], they reported no difficulties in using the proposed media on the SNS platform, as shown in Figure 7.

Multimodal representation

Because the media described in the previous section take the form of an ordinary image, it can be shared through the current platform while preserving its compatibility. However, the gesture information must be replaced with another modality if it is to be reconstructed *physically*. By defining the interaction context as asynchronous mediated human-human interaction over the SNS platform, we could select the haptic modality as a substitution method to represent how the motion in the haptic information is exchanged in the case of direct human-human interaction, such as a handshake. Therefore, in this interaction scenario, a haptic device conveys motion information haptically *instead of* another person in an asynchronous manner. Although the rendering platform is different, the use of haptic feedback in this scenario is supported by previous researches on touch [1, 2], the findings of which revealed that a recipient of a message with haptic feedback tends to estimate the intention or emotional status of the sender. In other words, the objective of these approaches is to allow impressionistic but not exact communication. Figure 6 illustrates the architecture of tangibly enhanced SNSs. From this part,

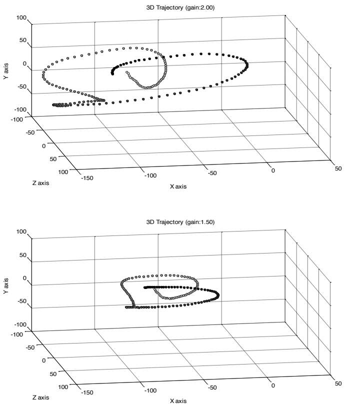

Figure 8. Example trajectories driven by the same acceleration profile with different force scaling gains

Figure 9. Example of an implemented haptic QR code reader. Once decoded, the system determines binary haptic information for vibrotactile rendering.

we propose a simple haptic rendering method that can be easily incorporated into a SNS. To avoid the abstract mapping issue that often arises when using 1-DoF tactile feedback, kinesthetic rendering with a commercial force interface, the low-cost haptic device PHANTOM® Omni™, was utilized in this implementation. Once the gesture information is reconstructed from the proposed images, the force vector (F_i) in a Cartesian coordinate system of the i^{th} axis can be calculated on the client side as a function of the reconstructed acceleration values.

$$F_i(t) = f\left(\hat{v}_i(t) - \hat{v}_{m,i}(t)\right) \quad (2)$$

Here, $\hat{v}_i(t)$ and $\hat{v}_{m,i}(t)$ are the interpolated acceleration to ensure 1kHz haptic rendering and the corresponding mean value, respectively.

Because the mean value, which is affected by gravity force and/or draft error, can result in unintentional force bias during kinesthetic rendering, it must be removed during the calculation of the force vectors. Once the force information is determined by Eq. (2), the haptic arm then moves the user's limb, which is *passively* located on the device. Giving up the faithful copy of the *trajectory*, a specific group of people can experience the force information composed by a user. The exerted force feedback helps the user to feel or estimate the original motion. In fact, this interaction is similar to record and playback strategies in that the recorded dynamics of a specific user is unilaterally transferred and played back. The proposed gesture-to-force conversion method has another advantage in that the gesture information can be played back with scaled force and/or time. Despite the fact that force scaling is applied to numerous traditional haptic systems, the scaling in this research plays a different role in allowing a user to amplify the previously logged *free motion*. Figure 8 shows examples of different trajectories created during passive haptic interaction in which the haptic system was driven by the reconstructed gesture data $\hat{v}_i(t)$. The intensity of every trajectory color in Figure 8 is linearly proportional to the elapsed time. The exerted force feedback with the elapsed time induces movement of the hand in the 3-D space. The trajectory can be altered according to the grabbing force of the user.

Discussion

Although we propose two types of 2D tangible code as a practical modality to describe a personal experience, there is a limiting issue in that most ordinary users do not have high-fidelity haptic devices. To involve general users in this platform, including the experience of the haptic information, our research group is currently focusing on sensory substitution with vibrotactile feedback so that a hand-held device can be used for both persuasive authoring and as an experiencing tool. This approach, which is at an earlier stage, is based on the previous research[4] pertaining to mediated vibrotactile interaction [1-3]. Figure 9 shows an earlier implementation of the vibrotactile QR reader.

Conclusion

Tactile proximity inherently provides a user with an experience that is higher in the sense of connectedness or intimacy than explicit information. In this context, this study introduces two types of tangible media that function acceptably in the current SNS platform. In a media preference study, users agreed that the use of gestures is a type of implicit personal media which can sometimes be dedicated to a specific person. They reported no difficulties in using the proposed image in a current SNS platform, in this case the microblog platform. In terms of media consumption, we describe a tangible interaction scenario over a SNS by proposing a sensory substitution method of motion data with kinesthetic feedback. As an extension of the research on mediated touch, it is expected that the proposed media and their rendering methods will enhance the tangible experience in social media spaces.

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