Comptics: A System for Making and Sharing Haptic Experience

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ABSTRACT

We have developed a haptic system, Comptics, that enables easy and rapid making, playing, and sharing of haptic experience. Comptics is composed of a haptic stimulation device, wearable user interface, and design and communication protocols (DCP) on a computer that uses unhearable signals.

1. INTRODUCTION

In the current audiovisual content industry, many users shift from passive roles to active ones. As passive users, they mainly consume content created by professionals. As active users, they themselves create content. Examples include the many people who write poetry on Twitter and post photographs on Instagram. These shifts to active roles are largely possible thanks to technology and design innovations in devices, software, and platforms for recording, editing, sharing, and playback. As a result, we are seeing a dramatic increase in content accompanied by increasing content consumption, and even changes in user behavior as well.

Haptics is getting a lot more attention lately as a way to create next-generation content [3-7, 10-11]. In designing haptic content, merging haptics with audiovisual content is a key point because there are few times in our daily lives in which we sense only haptic sensation. Therefore, various devices that produce combinations of audio, visual, audiovisual, and haptic content have been reported [4-7, 10]. However, it is now important not only to experience this content but also to allow users to create their own content as well, shifting more passive users into active ones [3, 11].

Here we introduce the design and communication protocols (DCP) and devices, termed the Comptics system, that that enables users to design haptic content on a computer and experience the designed audio and electrotactile stimuli. In our DCP, specific auditory signals that are inaudible to humans are converted to programmable electrotactile stimuli, so anyone can easily design and re-design the timing, intensity, and inflection of the electrotactile signals, similar to how one would edit music on a computer. In addition, users can simultaneously playback electrotactile stimuli and know what experience they designed. The Comptics system realizes this rapid trial and error cycle in order to create a richer experience during the creation process of audiovisual content.

2. SYSTEM DESIGN

Comptics consists of digital devices such as a PC or a smartphone, the dedicated electrical stimulation device as shown in Fig. 3, and the wearable user interface as shown in Fig. 6. The operational flow of Comptics can be described in three steps: design, signal processing, and output.

1. Design: Users program specific auditory signals with desired timing on consumer video or music editing software (e.g. Adobe Premiere Pro [1], Apple Garageband [2]).
2. Signal processing: The specific signals are extracted and converted to electrical stimulation signal on the device paired with Bluetooth.
3. Output: The device simultaneously plays sound and outputs the electrical stimulation signal via a headphone/speaker and electrodes, respectively.

2.1. Electronics design

The specific signal, termed the unhearable sound, is embedded in the 19-kHz band with the purpose of residing in the same sampling band as existing music file formats (e.g. AAC and mp3), is difficult for the human auditory system to detect, and has a low spectrum density for music and sound. Bipolar pulses

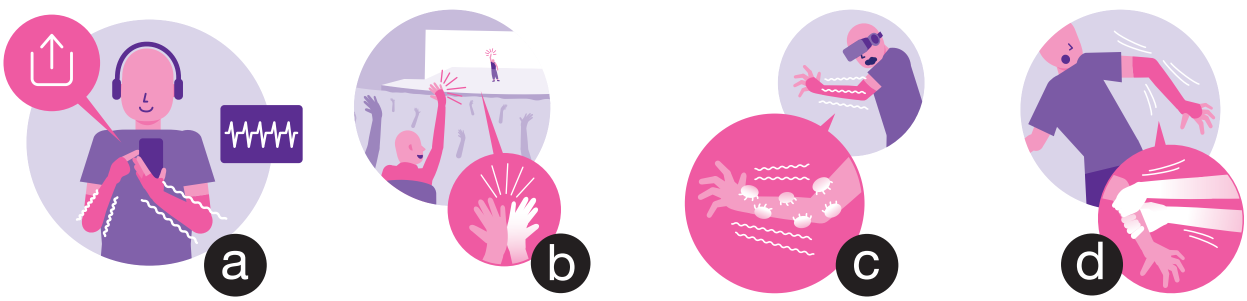

Figure1. Comptics envisions haptic interactions and experiences into internet services and entertainment.

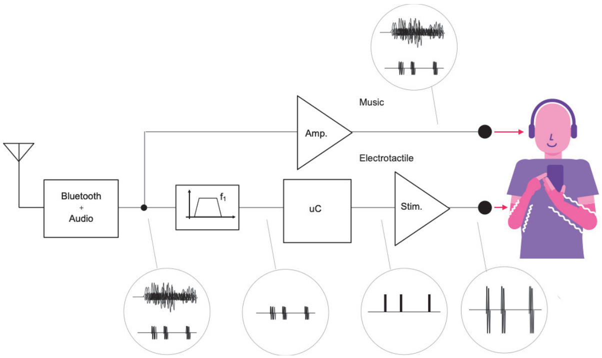

Figure2. Block diagram and signal processing

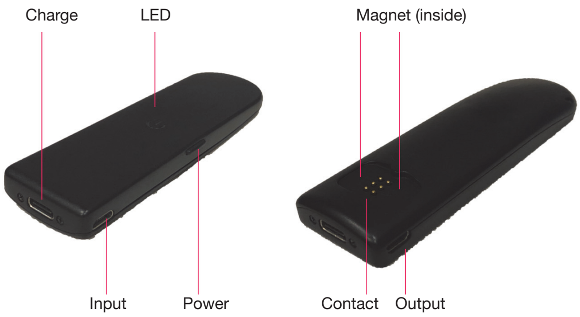

Figure 3. Overview of the Comptics device has four I/O ports for input source if wireline connection, output sound, charge, contact with the connector implemented in the textile.

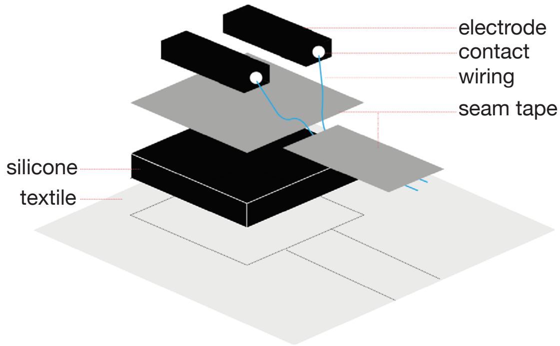

Figure 4. Electrode module structure.

Figure 5. The positions of the two electrode modules for right forearm.

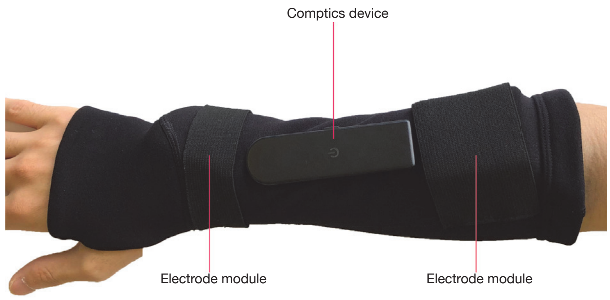

Figure 6. Overview of the wearable interface including Comptics device and two electrode modules.

are output once when the embedded signal is 45 ms, which is a margin for preventing pulses from being output by music or noise. The number of pulses output every 5 ms is set for a signal of 45 ms or longer. Of course, it is possible to change this setting by changing the firmware. The device consists of an RF audio circuit (RF52, Microchip Technology Inc.), filters for 19 kHz, a microcontroller (RX63N, Renesas Electronics Corporation), and an electrical stimulation circuit. The RF circuit is a Bluetooth chip corresponding to the Advanced Audio Distribution Profile (A2DP). The digital data from a PC/Smartphone is converted to an analog audio signal by the digital to analog converter (DAC) in the RF52. The analog audio signal is branched into two paths, one for music and the other for haptic output. In the former, a music signal including the embedded specific signal is output via an audio amplifier. In the latter, only a signal in the 19 kHz band (i.e., the specific signal for haptics) is extracted by an analog filter and converted again to a digital signal by an analog to digital converter (ADC). The microcontroller converts the extracted digital signal into a trigger signal of electrical stimuli based on parameters in the conversion algorithm. The gates of the electrical stimulation circuit are controlled by the trigger signal from the microcontroller. Amplified audio signal and electrical stimuli are respectively input to users via a headphone/ speaker and electrodes.

2.2. Wearable design

The electrode module consists of an electrode pair, seam tape, silicone used as a spacer, wiring between the connector and electrode, and base textile to wear the device as shown in Fig. 4. The textile electrode is composed of material developed by applying conductive fiber, such as silk, with a conductive polymer (poly (3,4- ethylenedioxythiophene) poly (styrenesulfonate): PEDOT-PSS) to nano fiber [8, 9]. This technology improves adhesion to the skin. Seam tape isolates each electrode, even though the electrodes are wet.

In order to cover individual variations of body composition, we investigated efficient electrode

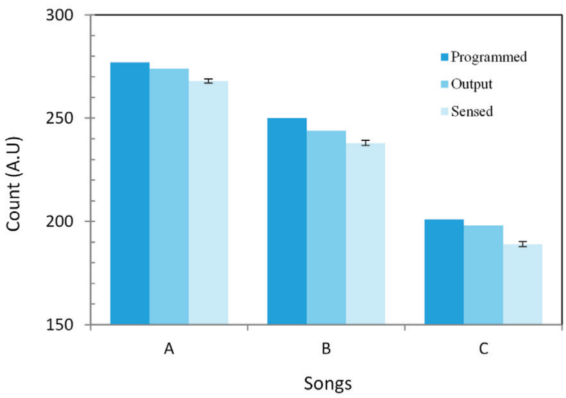

Figure 7. The measurement results of programmed signal numbers, output pulse numbers, and sensed stimulus for three different songs A, B, and C. (Error bars display standard error, n=3) Comptics envisions virtual and real haptic interaction

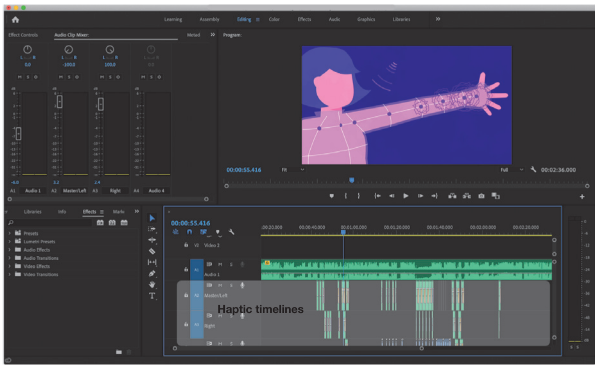

Figure 8. Sample image of the creating process of visual, auditory, and haptic timeline on the commercialized video editor (Adobe Premiere Pro [1]).

positions. There were 11 participants (8 males and 3 females), aged 26 - 61. In the user test, participants wore an armband with a thumb hole, and the armband was fixed at their elbow. We put a sticker, which is the same size as an electrode module on their wrist and forearm to cover the styloid process of ulna and brachioradialis muscles respectively. Figure 5 shows the test result (red dot) and final position (black dot).

Figure 6 shows the overview of the wearable interface including the Comptics device and two electrode modules. We employed an arm band which has a thumb hole in order to fix two electrodes to accurate position we designed. The Comptics device is held on to the textile between electrodes by magnetic force. The connector implemented in the textile has two magnets and six electrical contact points to the device.

3. PERFORMANCE

To demonstrate the feasibility of the Comptics system, we measured the output pulse number as the electrical stimulus for the amount of tactile information embedded in various test songs. Figure 7 shows measured counts of programmed, output, and sensed signals for three test songs, labeled A, B, and C. We realized a conversion rate of 98.3% on average. Some pulses are not output because, to meet safety standards, the conversion algorithm was designed so that it does not output a pulse if the interval is too short. In addition, humans have a limited response speed to haptics stimulus, and it is difficult to discriminate pulses if the pulse interval is too short. As a result, the number of pulses that can be sensed is also decreased. Battery life was over 2.5 hours, measured under the condition of a sample content. In the actual demonstration at the event, we confirmed battery life was over 2 hours.

4. APPLICATIONS AND DEMONSTRATIONS

Project Comptics envisions haptic interactions and experiences into internet services and entertainments as shown in Fig. 1. We are developing four applications as follows;

A. Create and share your own “touch”: Comptics enriches online communication and digital experiences where people can create, share, and replay tactile stimuli along with visual and auditory content.
B. Interact with performers: Audience members feel a closer connection with performers through Comptics experiences. For example, Comptics allows performers to share the same sensory touch they feel with the audience.
C. Guide in different way: Comptics has the potential to be the new way of guiding users without relying on sight. It can also be used as a new way of providing hints and notifications within an entertainment or gaming context.
D. Add tactile sensation to virtual content: Comptics can add reality and immersion to VR and imaging content dramatically.

Comptics enables users to create haptic content with audiovisual content simultaneously and rapidly as shown in Fig. 8. The device has two channels which is assigned to the right and left audio channels respectively. A content creator can design intensity, timing, frequency, and inflection or choose patterns from the preset library. This content can then be exported as an audio file or a video file and easily shared online. Users can then make interactive content by importing extracted haptic stimulation data and allowing users to se triggers with in a design tool.

We have demonstrated the prototypes of these applications to potential customers at several events as shown in Fig. 8. and received high amounts of feedback from various perspectives.

Figure 9. Demonstrations of some concepts and getting feedbacks from various perspectives.

5. DISCUSSION

This paper showed a proof of concept for creating, playing, and sharing a haptic experience implemented in a garment. However, practical issues remain for daily use. Because the prototype is not perfectly robust to compensate the individual variations, improvement of the user interface design is required. Textile electrodes without metal has the advantage of safety and comfort but low conductivity makes the need to keep moisture for reducing resistance. We need to develop higher conductivity textile electrodes or employ other electrodes. Although creators can now design timing, intensity, frequency and inflection, we plan to improve the conversion algorithm and DCP to provide more design parameters. Nevertheless, it is indicated that the experience of easily creating, playing, and sharing haptic content can be effective and an important direction of designing future interactive experience.

We obtained many feedbacks and insights thorough demonstration experience and find new interactions and experiences. The effectiveness of providing haptics highly depends on the context, and context design is a significant part as well as content design. In addition, providing good usability and comfort is obviously important before, during, and after the experience. Finally, we want to extend Comptics beyond audiovisual content to various interactions such as those involving motion and playing musical instruments. These improvements will provide a richer user experience.

6. CONCLUSIONS

We have presented our approach to easily creating, playing, and sharing haptic experiences by designing our DCP, embedding haptic data in an audio signal, and using the low-power stimulation device. We hope that our current work brings the vision of computer haptics in daily-life one step closer to reality. From the demonstrations and user studies, we leaned the effectiveness of our system that allowed users to easily create, play, and share their content, and importance of context design as well as content design.

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