TACT-21: Tactile Display Devices and Their Practical Applications in the 21st Century

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***Abstract*—Tactile display devices have been gaining an increasing popularity in human computer interaction, with a multitude of practical applications, in industry, entertainment, education, medicine etc. They are often used in virtual environments, embedded in consumer electronics and wearable devices, or, very importantly, as an aid or substitute to visual feedback for the visually impaired. The objective of this track is to bring together researchers with work on a) tactile display devices, b) tactile communication in mobile environments, c) wearable tactile displays, and d) machine learning and tactile information.**

Keywords-tangible interfaces, tactile display devices, tactile sensors, tactile communication, wearable tactile displays, pressure and vibration based tactile devices, electrostatic tactile displays, vibrotactile stimulation, tactile communication in mobile environments, machine learning and tactile information.

I. INTRODUCTION

In recent years, tactile displays have been gaining an increasing popularity in human computer interaction. A tactile display device can be defined as "a human-computer interface that can reproduce, as closely as possible, the tactile parameters of an object, such as shape, softness, surface texture, roughness, vibration and temperature" [1]. In humans, tactile sensations are perceived through mechanoreceptive units embedded in the outer layers of the skin; these transmit signals to the brain when stimulated [2]. Thus, tactile displays can serve as an alternative for information transmission through the stimulation of the human skin to induce tactile perception [2].

There are many applications for tactile displays, in areas like medicine, industry, education and entertainment. To give only a few examples, a large number of research works deal with using tactile displays as aids for the visually impaired. Tomita et al. developed an electrostatic force-based tactile display which allows the visually impaired to recognize and draw figures via tactile feedback [3]. Leo et al. provide strong evidence applications for the effectiveness of pin-array tactile displays in "enhancing spatial skills in people who are visually impaired in educational and rehabilitative contexts" [4].

As discussed by Kurogi and Saga in [17], several researchers are considering methods of presenting tactile texture information using vibration information from various viewpoints (e.g. [5]). Romano et al. proposed a method for recording texture on a tablet by recording acceleration, position, and contact force overtime when touching a texture with a dedicated tool [6]. Saga et al. proposed a simpler recording/playing method by omitting the measurement of pressure and using a compensation method when reproducing vibration [7]. In their work, the sense of direct touch is reproduced by recording vibration information with fingers and reproducing the recorded information by using the shearing force presentation device (as shown in [17]).

Several scholars have used GANs to generate data for tactile displays. For instance, Ujitoko et al. [9] employed a GAN generating timeseries data equivalent to texture images. Their model featured an encoder and a generator that, respectively, transformed texture images into labeled vectors and generated spectrograms using the recoded accelerations and the labels. The spectrograms were transformed into tactile signals for pen-type vibrotactile displays, as shown in [17]).

Many more applications of tactile displays are researched and put into practice in numerous fields. Through this special session, we hope to draw attention to this field and encourage more researchers to pursue work in this area.

II. SPECIAL TRACK CONTRIBUTIONS

The first contribution ("Simple Generative Adversarial Network to Generate Three-axis Time-series Data for Vibrotactile Displays", S. Agatsuma, J. Kurogi, S. Saga, S. Vasilache, S. Takahashi [10]) proposes a simple Generative Adversarial Network (GAN) to generate three-axis time-series data for vibrotactile displays. In the first step, vibrotactile acceleration data is generated, by acceleration data collected from rubbing real objects. With the aid of a GAN [13], the data can be used as output signals for vibrotactile displays [11][12]. GANs generate images that find many applications in super-resolution [14] and audio synthesis; some sounds are very similar to the human voice [15][16]. The used data generation model is based on WaveGAN [15], which was developed for audio synthesis. A user study was conducted, employing a vibrotactile display to evaluate whether the vibrotactile stimuli were realistic. The paper's principal contribution is the generation of time-series data using a GAN originally developed for audio synthesis. The training data of the model is based on accelerations recorded by rubbing real objects. The proposed model has a relatively simple architecture and does not require rich computational resources. Three-axis time-series data for vibrotactile displays is generated, facilitating the analysis and recognition of tactile signals.

The second contribution ("Rendering Method of 2-Dimensional Vibration Presentation for Improving Fidelity of Haptic Texture", J. Kurogi and S. Saga [17]) proposes a rendering method to reproduce biaxial acceleration information through a lateral-force-displaying device using X–axis and Y-axis vibration information. A new rendering method to display multi-dimensional vibration is proposed and, by comparison with conventional methods, results of experiments on the reproducibility of tactile sensation are reported. Moreover, in order to improve fidelity for large-scaled textures, combining image features information of the textures was implemented. The fidelity of the proposed method was evaluated through experiments; the results suggest that the proposed method can present randomized textures and periodic textures more precisely than conventional methods.

III. CONCLUSIONS

The tactile displays filed has become increasingly popular, with applications in many fields. The TACT21 special track has brought together two contributions that only deal with a small set of challenges. We believe that many research projects will continue to address the numerous applications of tactile displays and will bring various solutions which will improve our daily lives.

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