

# TorsionCrowds: Multi-Points Twist Stimulation Display for Large Part of the Body

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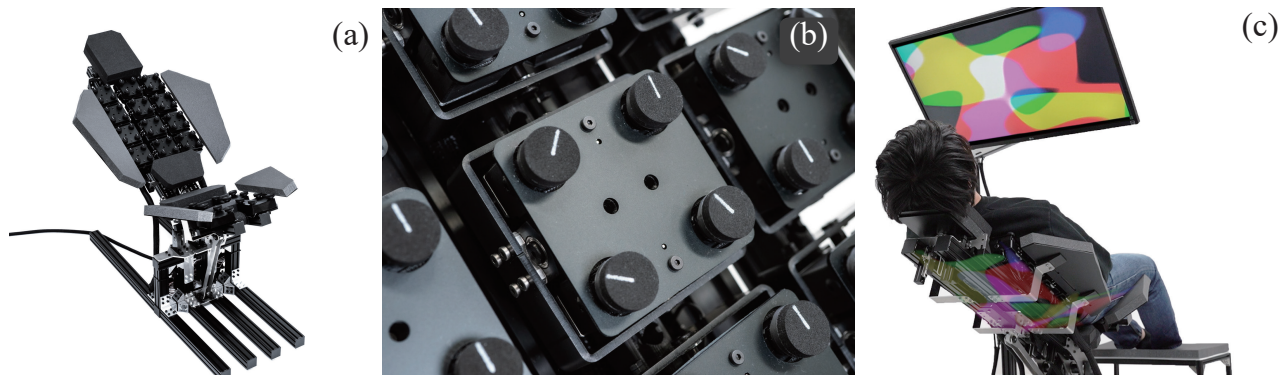


Figure 1: (a) TorsionCrowds is a seat type haptic presentation system. (b) Enlarged view of the device. The device has 64 channel twist stimulus elements. (c) The proposed system provides various force distribution on the user's back and buttocks.

## ABSTRACT

Humans perceive mechanical phenomena on the skin from the distribution of stimuli. In this paper, we propose TorsionCrowds, a novel tactile display that presents force stimulus distribution over a large area of the body. The system consists of multi-channel twist skin deformation modules and the passive mechanisms for fitting to the human body curve. By stimulating elements arrangement based on perceptual experiments, the user can perceive continuous force distribution in a large area of the body sharply with a high dynamic range of intensity. In the demonstration, the user can experience the force distribution from the system suitable for each scenario such as visual haptization, self-motion presentation, proprioception substitution.

## CCS CONCEPTS

• Human-centered computing → Haptic devices.

## KEYWORDS

haptics, skin deformation, whole-body experience, enhance perception

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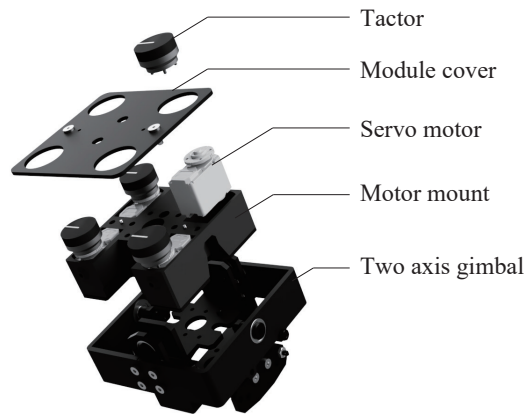
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## 1 INTRODUCTION

Providing immersive experiences by presenting haptic sensation to a large area of the human body have been mainly realized by vibration [Israr and Poupyrev 2011]. Vibrations are expected to increase event awareness in VR and remote control. On the other hand, it is difficult to present stimuli for a long period of time from the point of view of adaptation. Although a research has been conducted to present static forces using airbags [Delazio et al. 2018], the resolution and intensity of the dynamic range is limited.

Skin stretch is one of the methods that can present a static force that transmits stimulation by shearing deformation on the skin [Gleeson et al. 2010]. In recent years, it has been applied not only to the fingers but also to a wide range of areas such as arms [Bark et al. 2010], buttocks [Horie et al. 2018], and so on. Various effects such as force, the substitution of proprioception, and self-motion have been confirmed.

In this study, we present "TorsionCrowds", a tactile display with array of rotating factors that present skin stretching. This chair-type device presents twist stimuli to a wide area of human body as shown in Fig. 1. Static stimuli are presented by controlling the intensity



**Figure 2: Each module contain 4 stimulus elements and combined with two axis gimbal mechanism.**

of the stimulus by deforming the skin according to the angle of rotation. It is possible to do so. The multiple actuators present a spatially expansive stimulus distribution to create a realistic Realize a high level of sensation and expression.

## 2 PRINCIPAL AND SYSTEM

Each stimulus element of TorsionCrowds causes shear deformation of the skin as the tactor rotates. It has been experimentally confirmed that each stimulus element can present the magnitude of force according to the angle of rotation. By controlling the rotation angle of a large number of spatially arranged stimulation elements, it is possible to create and reproduce the spatiotemporal distribution of the magnitude of stimuli. Since the twist stimulation deforms skin shearing direction, it is not necessary to support a load applied vertically to the stimulating element as an output, so the system has high energy efficiency. Furthermore, it has been confirmed that human hairy skin has a wider dynamic range than vertical force, so it is expected that the user can feel a wider range of force intensity than normal pressure distribution.

The system consists of the tactile presentation units shown in Fig.1(b) and the body fitting mechanisms. A tactor made by polychloroprene sponge is attached to the tip of each servomotor to avoid slip and pain caused by edges. The maximum angle of each servomotor was 50° in each direction from the reference position, which was the maximum angle experimentally confirmed that no slippage occurred under sufficient pressure. The system has 64 independent stimulus elements, 48 channels for the back and 16 channels for the buttocks. Each servo motor is mapped in space in the computer, and the servo motor at any position can be controlled at any angle.

Each module consists of four servo motors, and is supported by a two axis gimbal mechanism with its own weight guarantee as shown in Fig.2. The gimbal mechanism makes it possible for the tactor to keep vertical contact with the body and present a stable twist stimulus. Furthermore, by combining with a mechanism that eliminates the offset between the left, right and the center of the back, it is possible to apply even pressure to the skin on the tactors.

## 3 USER EXPERIENCE AT SIGGRAPH

At E-tech of SIGGRAPH 2020 attendees can experience three kinds of applications using the proposed haptic display.

### 3.1 Visual Haptization

The system generates haptic stimulus distribution from visual images. The user can feel the shape of the animation sharply on their body as if the animation has a physical entity as shown in Fig.1(c). In addition, he/she also can experience the haptic sensation of visual effects such as an explosion, fade, flash, etc. of the video, it provides the immersive watching experience to the user.

### 3.2 Inducing Self-Motion Perception

The user controls a vehicle in the simulator and perceives the force distribution caused by spacial movements such as acceleration, deceleration and centrifugal force in real-time. In the simulator, our system calculates acceleration value in the 3D space and determined the presenting force distribution based on precomputed FEM analysis. It is known that force presentation on a large area of the body induces a self-motion sensation[Horie et al. 2018].

### 3.3 Proprioception Substitution

Skin shear deformation is often used as a substitution of proprioceptive sensation[Bark et al. 2008]. The proposed method can present shearing stimuli to a large area of the body, and substitute the sense of proprioception of large body movements such as walking, waving arm, and so on. When the user receives a stimulus based on the skin deformation due to the avatar's movement, the user gets strong body ownership to the avatar.

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