



TOUCHLESS: Demonstrations of Contactless Haptics for Affective Touch.

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ABSTRACT

A set of demonstrators of contactless haptic principles is described in this work. The technologies are based on electrostatic piloerection, chemical compounds and ultrasound. Additionally, applications related to affective touch are presented, ranging from storytelling to biosignal transfer, accompanied with a simple application to edit dynamic tactile patterns in an easy way. The demonstrators are the result of the Touchless project, which is a H2020 european collaborative project that integrates 3 universities and 3 companies. These demonstrators are contactless haptic experiences and thus facilitate the come-and-interact paradigm, where users can approach the demo booth and directly experience the applications without having to wear devices, making the experience fast and hygienic.

CCS CONCEPTS

• **Human-centered computing** → **Haptic devices**.

KEYWORDS

haptics, affective touch, ultrasound, piloerection

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1 INTRODUCTION

Although touch is vital for how we feel and interact with our environments and is foundational for our emotional well-being, most haptic technologies have focused on its functional aspects, helping people to improve task completion time, discriminate between

shapes or textures, and grasp virtual objects. This kind of haptics relies mainly on triggering mechanoreceptors on the palm and fingertips through a tactile glove or wearable, thereby increasing immersion and presence.

In contrast, non-functional aspects of touch relate to our sense of agency, trust, and attachment, and are more experiential. Social touch for example involves the stimulation of non-glabrous (hairy) parts of the skin [16] while also affecting nociceptors (pain) and thermoreceptors (temperature). These C-tactile (CT) afferents underpin the experience of affective touch, and the pleasant sensations associated with social interactions such as caresses [10].

In the following set of demonstrators, we present the technologies and applications developed in the first 2 years of the European Project TOUCHLESS, which at its core aims to develop contactless haptic technologies that generate sensations not only on the palm and fingertips but also on other body parts more connected to affective and experiential responses. Moreover, the project aims to teach AI systems to synthesize and use these touchless haptic interfaces in order to improve our sense of agency, trust, and attachment.

2 DEMONSTRATORS

2.1 Electrostatic Piloerection

The users will experience piloerection mainly in the forearm and nape. An electrode is placed above these areas and charged with electrostatic charges, by induction the hairs get the opposite charge and are attracted. These sensations can be similar to the goosebumps or chills that we get due to fear or awe.

Piloerection occurs in response to a strong emotional reaction and has been linked with both positive and negative emotions. For example, Darwin suggested that piloerection occurs in response to anger, fear, or excitement. Yet, for a given emotion, there are studies that connect it to piloerection whereas others found no association [17]. Some works have used artificial piloerection. For example, in MagHair [3] they apply ferromagnetic powder in the user hair for being able to move it with electromagnets placed at the other side of the forearm. There have been excellent exploratory works in using electrostatic fields to create artificial piloerection in the forearm [8, 9].

When users try this demo, an electrode will be placed above different body parts such as the nape or the forearm to induce artificial piloerection Figure 1.left. The electrode can be placed above different body parts, switch on and off at different speeds, and moved manually for dynamic patterns (e.g., caresses on the forearm). The system schematic is shown in figure 1.left.

2.2 Narrated stories augmented with tactile patterns

We have created a semantic mapping between text to haptic sensations delivered by mid-air haptics, and apply this mapping to an emotional short story narrative. The result is an immersive audio-haptic experience (no visuals).

Haptic technologies have previously been used to improve meditation by means of vibrating or ‘breathing’ pillows [5, 11]. Handheld pebble devices can enhance remote storytelling to children [15].

Vibrating vests have been shown to enrich story listening [13]. In these works, different ‘feel effects’ (FEs) were designed (i.e., haptic patterns) and were associated either to bio-feedback, user input, or to a set of events and keywords taken from the story narrative.

Our demo explores how touchless haptic technologies such as ultrasound mid-air haptics can enhance story listening and self-meditation practices. The main contributions are the semantic text-to-haptic mapping (see Figure 2b, d), and the walk-up-and-use setup without having to hold or wear anything besides some headphones (see Figure 2a) [22].

With text generation becoming increasingly democratized through AI tools like ChatGPT, this demo invites discussion on how we can automate and democratize haptic design in immersive experiences.

The demo can be experienced while standing or sitting down. An Ultraleap Stratos eXplore (USX) device is positioned on a table and connected to a PC (see Figure 2a). The user is provided with headphones and selects the audio voice playback (male or female voice). A 2-minute audio story follows. It is about a person who returns to his/her destroyed home after a long absence inspired by the war in Ukraine. The narrative reveals the deep emotional and sensory experience such as rain, wind, car engine, a staircase, door opening/close or heartbeats. These sound effects as well as some of the narrative keywords are haptically presented as different semantically congruent haptic patterns (analogous to the FEs in [13]) onto the user’s palm which is resting at about 15 cm above the USX. The audio-to-haptic mapping (see Figure 2b,d) was heuristically constructed and invites further research.

2.3 Biosignal transfer mediated by haptics

We have developed machine vision algorithms that extract biosignal time-series (heart rate & heart rate variability, emotion recognition, valence and arousal estimation) from a video recording of the user’s face [2]. Then, we playback the video recording along with touchless haptic sensations that mimic the heartrate time-series.

Sharing of biosignals can add value in disambiguating or enriching online communication [7]. For example, displaying one’s heart-rate can result in increased trust, higher levels of engagement, and empathy [14]. In a recent study, we demonstrated significant changes in arousal and valence as well as in a variety of physiological responses such as heart rate, respiration rate, and eye gaze as a result of biosignal feedback during a video call enhanced by mid-air haptics [12]. This demo builds on our prior work, showcasing both the unobtrusive biosignal extraction from video [2], and how these could be re-mapped through a touchless tactile channel.

The demo application runs on a laptop and is experienced while sitting down and resting one hand on an open-top box containing a mid-air haptic device (see Figure 3). During the interactive demo, the user first records a short video clip clearly showing their face. The app then processes the video and extracts a number of biosignal time-series (heart rate & heart rate variability, emotion classification, valence, and arousal estimation), and uses them to dynamically adjust properties of the mid-air haptic pattern, thus creating a haptic time-series of equal length as the video recording. In the last phase of the demo, the user (or any other user) can replay

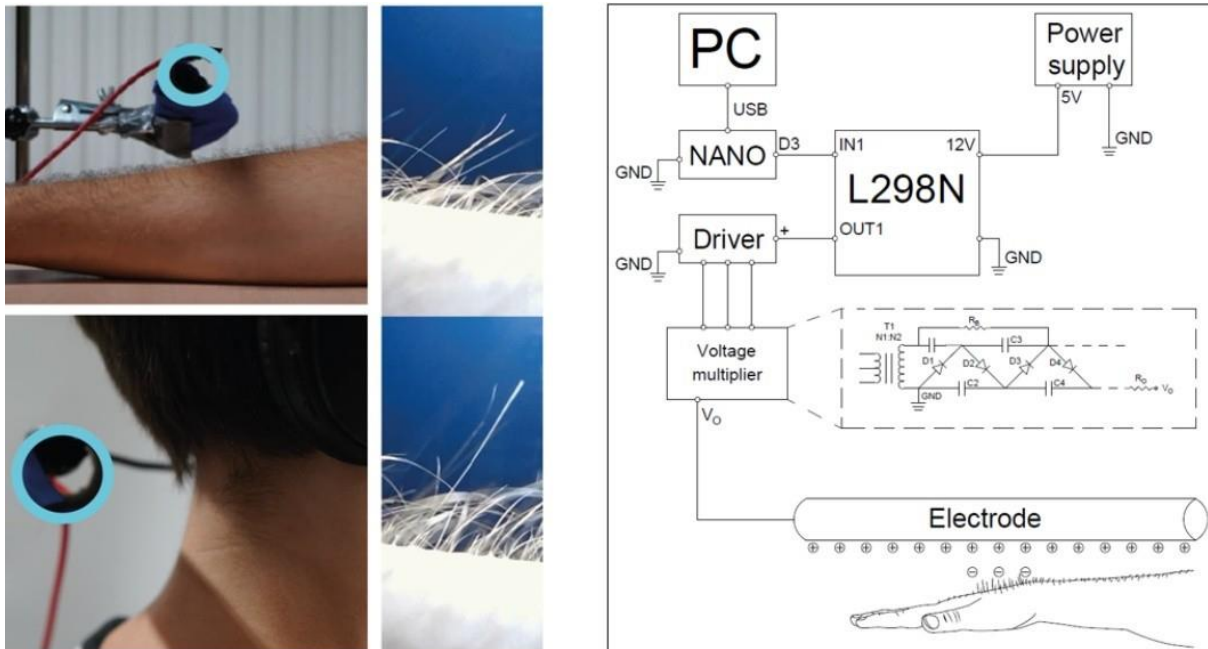


Figure 1: Left) A user experiencing the demo on the nape and forearm. Center) on the top the hairs are not raised, on the bottom, the artificial piloerection has been switched on. Right) System for delivering controlled electrostatic charge into an electrode. A PWM signal is amplified by a L298N that powers the multiplier that outputs high voltage into the electrode. Inside the multiplier, there is a transformer (N1:N2 of 200) and multiple stages of a Cockcroft-Walton multiplier. □ is the bleeder resistor and □_o the limiting resistor.

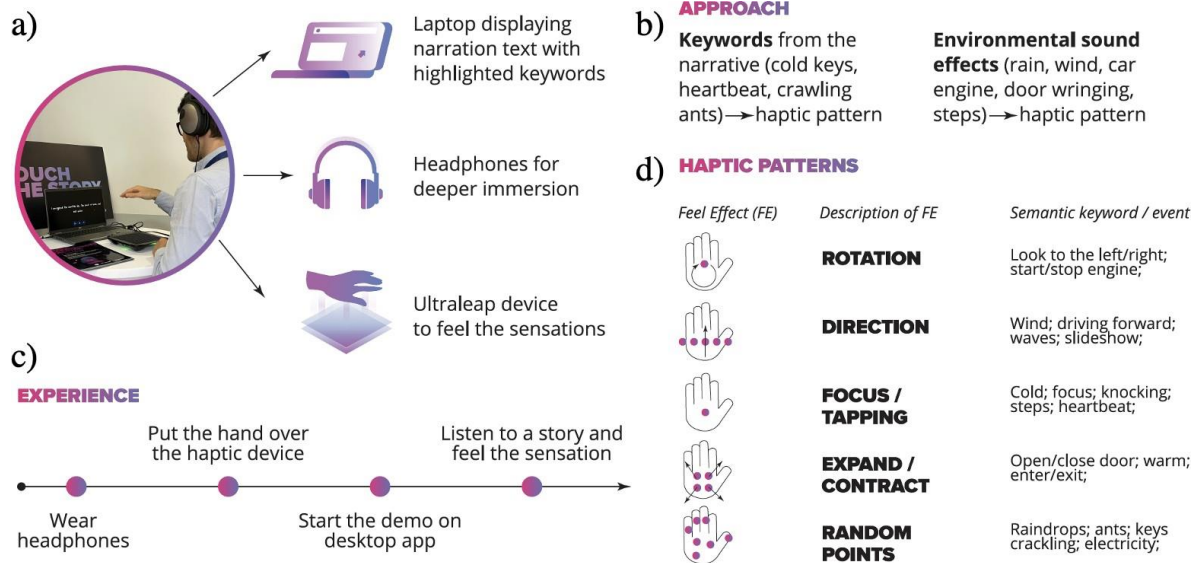


Figure 2: a) Touch the story demo setup and components. b) Simplification of how keywords and environmental events were chosen to be haptified. c) Demo user journey. d) Semantically congruent haptic mapping table.

the newly haptically enhanced video recording. No personal data is saved during this demo, unless consent is obtained *a priori*.

Our demo can provoke discussions on multisensory communication channels that are touchless and unobtrusive and that can

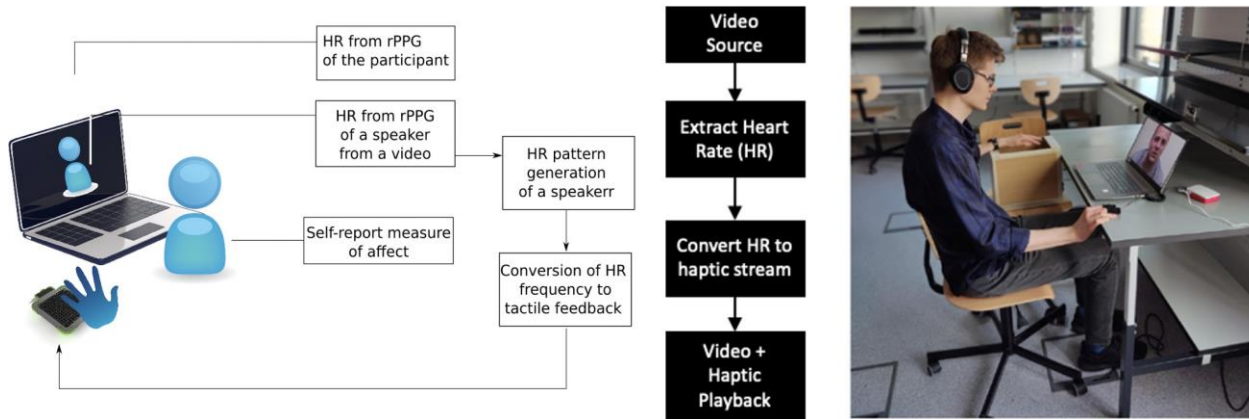


Figure 3: System architecture and demo experience setup.

enhance empathy, the sense of co-presence, and intimacy, with applications in communication, healthcare, and possibly XR and the metaverse.

2.4 Feellustrator: designing contactless haptic patterns on a desktop computer

This demonstration presents Feellustrator, a graphical design tool for creating custom haptic dynamic patterns. Users can then feel these patterns on their hands by means of focused ultrasound generated by an ultrasonic phased-array.

Ultrasound mid-air haptic technology provides ample possibilities for designing contactless touch experiences [18]. However, creating mid-air haptic experiences involves programming dynamic patterns that may also change depending on the hand and finger positions. This is an entry barrier for most designers [21] and limits rapid design exploration. Previous work on graphical design tools for contact haptics (e.g., vibration [19], force feedback [23]) improved design efficiency and the resulting patterns. Feellustrator is an application tool that allows designers to create spatial and

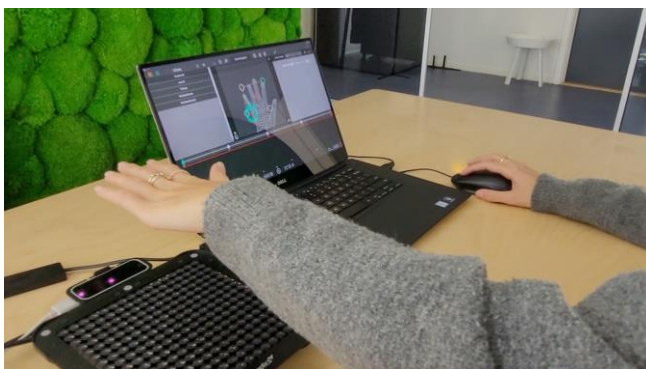


Figure 4: A user creating a custom ultrasound mid-air haptic pattern with Feellustrator and feeling the pattern with their hand.

temporal haptic patterns in an easy way. Its design was informed by ultrasound designers and users that tested the tool [20].

Feellustrator is a stand-alone application that runs on a computer with a Windows operating system. To feel the ultrasound patterns, the computer is connected to an Ultraleap STRATOS Explore device and a leap motion tracker. The design tool allows users to specify the pattern graphically. The parameters of the pattern are sent to the STRATOS Explore device and processed and rendered directly on the device.

2.5 Chemical Haptics

Hydroxy- α -sanshool, the main molecule contained by Sichuan pepper (hereafter sanshool), activates specific skin receptors involved in the perception of vibration, thus providing tingling sensations in absence of any tactile stimulus [1, 4]. In a recent study, Cataldo and colleagues [6] used sanshool to activate the somatosensory channel responsible for vibration perception and then tested whether this tingling sensation was modulated by sustained mechanical pressure. The authors found that sustained touch inhibited sanshool tingling sensations in a location-specific, pressure-level and time-dependent manner.

In this demo, a sanshool solution will be applied on the lower lip of the users. A few minutes after, the tingling sensation will reach maximal intensity and then plateau. Next, sustained pressure will also be applied to the same area of the lower lip using a disposable cotton bud. The users will perceive the effect of mechanical pressure on the chemical vibration sensation induced by sanshool. Users will also test the interaction with thermotactile sensations, disposable caps filled with warm/cold water or drinks from the conference will be used. Warm stimulation boost the tingling sensation whereas cold stimulation inhibits it [6].

3 CONCLUSION

Demonstrators from the European H2020 project Touchless will be made available for the attendants. They are focused on contactless haptic technologies with applications in storytelling and empathy through biosignal transfer. We hope that these demos stimulate further interest in using haptics for affective applications.

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