Demonstration of inScent: a Wearable Olfactory Display as an Amplification for Mobile Notifications

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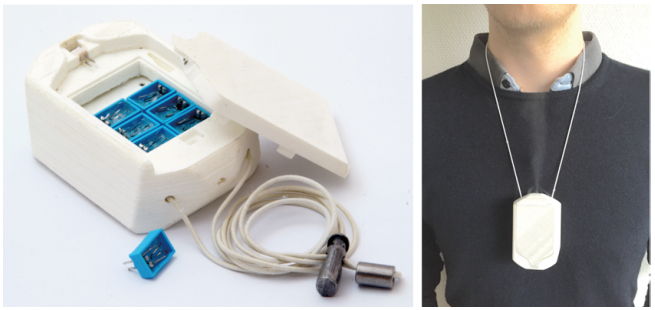

Figure 1: Left: The *inScent* prototype with opened top lid. Up to 8 scent cartridges can be plugged in. Right: The wearable is worn as a pendant. For this photo, we increased the amount of glycerol to make the scent emission visible as smoke.

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Abstract

We introduce inScent, a wearable olfactory display that can be worn in mobile everyday situations and allows the user to receive personal scented notifications. Olfaction, i.e. the sense of smell, is used by humans as a sensorial information channel as an element for experiencing the environment. Olfactory sensations are closely linked to emotions and memories, but also notify about personal dangers such as fire or foulness. We utilize the properties of smell as a notification channel by amplifying received mobile notifications with artificially emitted scents. We built a wearable olfactory display that can be worn as a pendant around the neck and contains up to eight different scent aromas that can be inserted and quickly exchanged via small scent cartridges. Upon emission, scent aroma is vaporized and blown towards the user. A hardware - and software framework is presented that allows developers to add scents to their mobile applications.

Author Keywords

Olfaction; scent-based notification; wearable device; olfactory display

ACM Classification Keywords

H.5.m. [Information Interfaces and Presentation (e.g. HCI)]: Miscellaneous

Figure 2: The *inScent* prototype worn on a necklace

Olfaction

The sense of smell is an important information channel that is strongly linked to emotions and memories. The stimulus of a scent can evoke memories that are more emotionally loaded than memories elicited through other senses. Contextually distinctive odors are especially good retrieval cues [5]. Furthermore, long-term odor memory is unusually well preserved beyond other sense memories [5]. When perceiving the environment, smell is often an essential part of the experience, e.g. smelling the leaves and trees when strolling through a vivid forest, or the familiar and intimate smell of the own home. But also independently, artificial scent is used to create or enhance experiences. Perfumes give oneself a pleasant personal scent, while for instance Mercedes-Benz offers a package to their premium cars that adds digitally adjustable fragrance to the air conditioning system. In aromatherapy, essential oils are used for expected personal well-being and many cosmetic products contain fragrances.

The unique properties of olfaction as a modality make smell-based interaction a promising field for HCI. We want to utilize artificially emitted scents to invoke emotions and experiences for users in everyday life situations by presenting *inScent*, a wearable olfactory display that can be worn as a pendant on a necklace (see Fig. 1). The primary use case is to complement and amplify received mobile notifications by using scent as an additional *emotional notification channel*. We call this *scentification*. Messages of the life partner can be emphasized by emitting a pleasant relating scent such as flowers or the other person's perfume aroma to reflect the emotional link to this person (see Fig. 3). Another example is using the alerting properties of smell to subtly remind of an upcoming event (e.g. a meeting). Our device contains up to eight different scent aromas in exchangeable scent cartridges that can be used for different applications and use cases. Upon emission, a scent aroma is vaporized. A small fan within the casing flows air through the device and gently blows scent towards the user's nose.

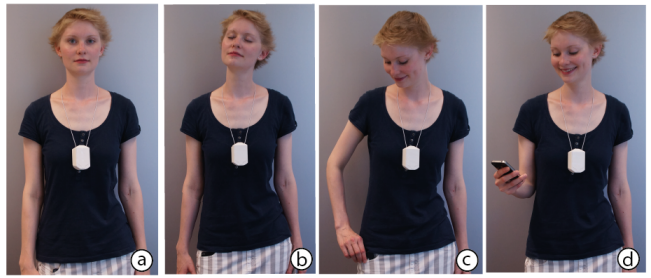

Figure 3: A user receiving a message of her parthner (a). She smells his scent (b) and in pleasant anticipation reaches for her phone (c) to read his message (d).

Computer generated scents so far have mostly been used as an ambient display [6], to enhance multimedia experience [4] or for memory recall [2]. Bodnar et al. [1] explored the properties of olfaction as a notification mechanism and found that it is less effective in delivering notifications compared to other modalities but also produces a less disruptive effect.

Olfactory displays in related work are mostly stationary. With stationary emission however it becomes challenging to create localized rather than ambient odor [7]. To allow for mobile scent delivery, we miniaturized the scent generation to a form factor that can be worn around the user's neck.

Wearable Olfactory Display

We demonstrate *inScent* [3], a wearable olfactory display that allows users to passively receive multiple computer generated scents in mobile everyday situations. We utilize

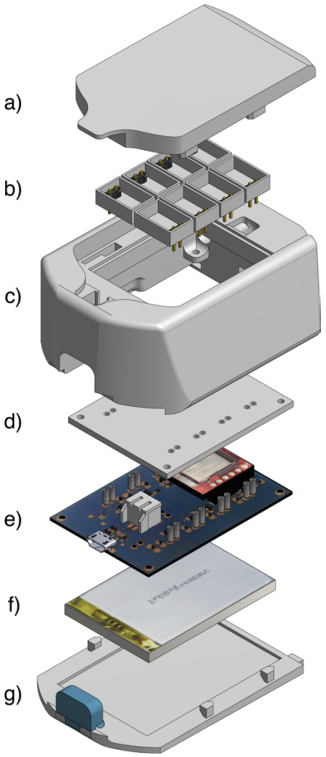

Figure 4: The *inScent* prototype from top to bottom: a) top lid including a hidden axial fan, b) scent cartridges each containing a heating unit and a different scent mixture, c) body case including hidden scent extraction duct, d) scent mount to isolate the scent chamber from the electronics, e) printed circuit board inlucidng *BLE Nano*, f) battery, g) bottom lid including rubber lid for charging port.

this to investigate the use of scents to amplify notifications, i.e. *scentifications*, in public scenarios.

Form Factor
We decided to build the device in a form factor so it can be worn as a pendant around the neck. The casing (8.4 x 5.9 x 3.1 cm) was 3d-printed and contains the other components: a scent chamber with up to 8 scent cartridges, a ventilation system, control unit, power management and a battery (see Fig. 4).

Vaporization by Heating
Vaporization by heating is used for scent generation to be able to control timing, duration and quantity of the scent emission. The heating process for each scent aroma is conducted within the respective scent cartridge (see Fig. 5). Scent cartridges can be filled with different scent aroma tailored to the user's and application's needs and are quickly exchangeable and pluggable into the device on the fly. Each cartridge incorporates a wire as a heating coil and an absorbing layer consisting of glass fiber to absorb the scented liquid and to consistently deliver liquid to the coil. The scented liquid is a mixture based on aromatic substance, high-proof alcohol and carrier liquid. Initially, the aromatic substances (ethereal oils) are pre-diluted with ethanol. Subsequently, the solution is mixed with a carrier liquid consisting of glycerol and polyethylene glycol (PEG). Both carrier liquids are highly viscous. In conjunction with the liquid mixture being soaked into the glass fiber, the high viscosity prevents leaking from the scent cartridge. The mixing ration was determined experimentally and was for instance 5% aromatic substance, 20% ethanol, 50% glycerol and 25% PEG for the scent aroma *orange*. The amount of aromatic substances can vary due to human olfaction perceiving different odors at varying intensity (e.g. we used only 2% aroma for *mint*).

Scent Delivery
After vaporizing scented aroma, the scented air has to be delivered to the user. A small axial fan is embedded in the top lid and vacuums the vaporized scent from the scent chamber and exhales it into a scent extraction duct on the upper side of the device facing the user's head. For scent emission, the fan, as well as the heating coil in the scent cartridge are powered for 5 seconds. Scented aroma vaporizes almost instantly in the scent chamber, but then takes a few seconds bridging the distance to the user's nose.

Power Management
For power supply we built-in a Lithium-ion Polymer (LiPo) battery that provides a nominal capacity of 510mAh. For *inScent* to be able to receive scentifications from a connected mobile device and to then drive the scent release, a *BLE Nano* was integrated, one of the smallest Arduino microcontroller that incorporates Bluetooth Low Energy (BLE) functionality. We manufactured a double-sided printed circuit board (PCB) to mechanically support and electrically connect all electronic components. The board features a slot for each scent cartridge over which the *BLE Nano* is capable of measuring current. This enables polling each slot to detect plugged-in cartridges. By itself the *BLE Nano* has only limit output current, which is why each slot draws the power directly from the battery which is switched by a transistor.

Including all components, the *inScent* wearable weighs 102g, can be used multiple days without recharging the battery and each scent cartridge contains aroma for approximately 70-100 *scentifications*. Assembly files, instructions and software are made available as open source at https://www.uni-ulm.de/?inscent.

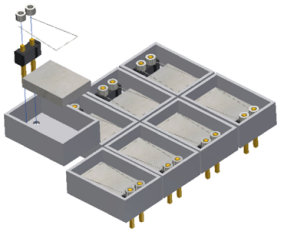

Figure 5: 8 Scent cartridges each containing different scent aroma. Scented liquid is soaked into glass fiber as an absorbing layer. Each cartridge contains a heating coil on top of the absorbing layer to vaporize by heating. The pins serve as a plug to connect to the mainboard and to hold the cartridges in place.

Software Framework

We built a software framework running on Android (ver. 5.1) as a background service that can be accessed by one or multiple applications. It is in charge of the control flow of *scentifications* including the connection with the device.

Scented notification

The framework allows to automatically amplify the phone's native notifications with emitted scents. A developer can define multiple trigger and events such as the name of the sender, the content of a message or a particular application (in any combination). Also, timing conditions are possible (e.g. 5 minutes before a specified calendar event).

Remote service

To also enable remote control for developers, we implemented a GCMService that allows the sending of push notifications over Google Cloud Messaging (GCM) directly to the running background service. This enables access to the framework from outside the phone and allows for its integration into other systems independently of system platform or programming language.

Conclusion

In this demonstration, we present *inScent*, a wearable olfactory display that allows the emission of scents throughout the user's day as a mobile amplification for notifications. Users can individually assign scents to applications and use cases using modular scent cartridges, while developers and researchers can create novel scent-based applications for wearable contexts using the introduced hardware and software framework.

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