This essay was chosen under the design subcommittee which involves scope for design thinking within HCI research.

Literature Survey: How smell can be a factor of use in HCI development? This has been a topic of research since the 1950s, a book published **called "Fragrance–The psychology and biology of perfume"** [1], which is an extension to the previous book **"Perfumery"** the study of Perfumery psychology. One of the first technological applications used odours to convey information and complement other human senses was the Sensorama[2], an arcade-like cinema projector for individuals invented by **Morton Heilig** during the early sixties, between sixties and late nineties, little research was carried out on olfactory interfaces, particularly for education and training. There was a lack of technological advancements in personal computers with enough processing power to support odour generation, no better ways to recreate, store, and release odours in HCI. Research teams in Japan, USA, and Europe also focused on the effect of essential oil and other odorous material on the human body and mind with effect on the brain in terms of mental and physical performance including moods (mental states). Since mapping happens between the odour and the emotional situations which are stored in the memory with the odour. As a result, when this odour is experienced again at another point in time, the memory of it along with the odour is retrieved. With this intense research of using odours as a factor to understand how human emotions are mapped to odour. The brain identifies relevant odour or olfactory sensations which is based on the patterns of an electrical pulse. The measure of **quality**(level of intensity the nose is possible to smell) and **quantity**(number of different smells it is possible to sense) is used as a metric for measuring its bandwidth. Perfumers and florists will be able to identify thousands of smells, unlike others who could identify just 16 smells reliably. Electronic noses which help in finding and understanding smells were developed, spray bottle with the help of inkjet technologies to diffuse scents was also in place. Scented computers web sites and Games, DigiScents' iSmell system [3] was built by **Macromedia** founder Marc Canter which attach their hopes on scenting websites and games: the smell of aromatic vodka as you visit Skyy website. Also, Symbolic olfactory display incense clocks, inStink- connecting two spaces using scent which involves display of activity in kitchen into a remote space (such as another kitchen), scented reminders (Microsoft outlook to set smell alarms - an aroma of a baby powder), dollars and scents – to predict the state of stock market (smells like mint if the market was up or lemon if the market was down) [4]. Using smell for searching digital photo collections called foto – photo browsing and searching tool (using smell cubes) called Dale air (an RFID disc tag) [4]. Emerging olfactory interface applications using virtual reality simulators to train U.S. soldiers in the military uses smells to enhance the ambient of a simulated war zone. The soldiers wear an electronic collar where the scents are generated, and each odour is activated through a wireless network, according to the activities done and events generated in the virtual scenario. For example, when soldiers shoot guns in the virtual environment, they perceive the smell of gun powder, generated by the electronic collar they wear. It is also technically feasible to use odours in virtual reality simulations for medical training since there are ways to activate them remotely over the Internet.

Research Study:

1) **Opportunities for Odour: Experiences with Smell and Implications for Technology (Published: 2014)** [6]
   Experiences and emotions related to smell and link them to potential technologies and exploring the implications of the categories for smell enhancing technology design by
   a) examining participants to envisage technologies that match their smell stories and b) HCI researches brainstorm technologies using these categories as design stimuli. Also discussing how these findings can benefit research on personal memories, momentary and first-time experiences, and wellbeing. Uses the power of smell in connecting humans to past events and experiences. An olfactory display system that can distribute smells. As part of this experiment 439 smell stories were collected, including personal memorable experiences involving smell. After analysis 10 main categories and 36 sub-categories were identified with respect to its experiential and emotional characteristics and specific smell qualities. The smell is particularly useful in inducing mood changes because they are almost always experienced clearly as either pleasant(smell of vanilla) or unpleasant(smell of Methyl Methacrylate). A web-based questionnaire consisting of size parts were chosen. The smell story where the participants were asked to describe smell experience in as much detail as possible (positive/negative), also to indicate if it was personal or non-personal. The context like the social context (who else was present), the place, the location, and the time. Smell technologies involving six inspirational examples: foto, smelling screen, digital smell, scent dress, mobile smell app, and smell-enhanced cinema. Personal background on their socio-demographic and cultural background to know the influence on smell attitudes. These stories were divided into 10 identified categories: associating past with the smell(major life events), remembering through smell (link from present experience), smell perceived as stimulating (first time experiences), smell creating desires (sensation of newness – to buy), smell allowing identification and detection(smell of anxiety – Gas leak), overwhelming power of smell (positive – smell from chocolate factory, negative – Smell of death (which can be traumatizing)), smell evading private and public spaces (mostly smell with negative experiences with lingering qualities), social interaction is affected by the smell (body smell), Smell changes mood, attitude and behavior, smell builds up and changes expectations(expectations to surprise).
2) **Sensing the Future of HCI: Touch, Taste, and Smell User Interfaces (Published: 2016)** [7]
   Understanding of people's multisensory experiences in HCI involving taste and smell. Understanding the ways in which the senses process information's that helps in creating a varied experience in human interacting technologies. Firstly, Olfactory experiences can be designed and used in technology interactions. Secondly, using the exiting multisensory design along with creating new ones. Thirdly, designing interfaces that allow simulation of unexplored sensory inputs, as well as the interfaces that consider the relationship between the senses. Lastly, the limitations that come into play while using more than one sense simultaneously. This paper builds upon the idea of the **"Digital Taste and Smell Communication[1]"** which was published in 2011. The challenges involved when studying about smell are related to inter-subject variability, olfactory preferences over time, and cross-sensory influences. The smell is one of the sensory modalities that make direct and intense contact with emotion and memory, which explains the reason why smell-evoked memories are emotionally potent. The smell is one of the known chemical senses as they rely on chemical transduction.

3) The power of our sense of smell: what technology can learn from humans (Published: 2017) [8]

Development of scent-delivery devices that are beyond environmental and healthcare services. Since this advanced smell-based technology use augment technology to use amplified sensory perception of people with sensorial impairment (e.g., blind and deaf). It provides a brief overview of the olfactory system, unique properties and related challenges facing HCI. Our sense of smell depends on sensing chemical molecules/components called **odourants**. Odourants detection is only a part of the olfactory experience. The olfactory system completes the smelling (sniffing) action which is smelling codification process by generating the appropriate internal representations in the brain unless it happens on an unconscious level. Recent researches in neural sciences have demonstrated how humans and animals can navigate space both my tracking smells and by following an olfactory grid [fig1]. The olfactory grid is a map constructed from chemical stimuli; humans can define an arbitrary location in the space. This human's ability to locate olfactory stimuli is exhibited through avoidance behavior based on contextual factors(e.g., identifying known and familiar people or places). Recent research has demonstrated that humans can discriminate more than 1 trillion of olfactory stimuli. The chemical components make sense of smell easy to discriminate. olfaction has unique properties associated with memories and emotions also defines as the 'poet' of sensory systems within neuroscience because of its complex structure. Since no other sensory system makes direct and intense contact with neural substrates of emotion and memory, because of which smell-evoked memories are emotionally powerful. Memories triggered by odours are older which are more emotional than that of verbal cues, which is also state-dependent, as it is directly linked to the event it was smelled the first time. The olfaction-emotion relationship is mainly due to shared common pathways of emotions and odour processing.

Fig1 Dog vs humans smells tracking abilities.

4) The Multisensory Experiences in HCI (Published: 2017) [9]

Using smell when designing interactive tasks, especially gaming, multimedia, and art environments. Multisensory experience in HCI is an approach which involves the use of different human senses and its relation in designing experiences that can have a major impact on society and consumer markets. Development of new products and service experiences involving ways for immersive storytelling and user's engagement with content. For example, Jenny Tillotson

introduced the idea of an interactive scent outfit, which is a smart second-skin dress that mimics the body's circulation system and emits a selection of scents depending on a person's mood[10]. Such concepts reveal the potential of blending sensory research with biometric sensors for a more natural interaction, which is supported by recent technological advancements in mobile, sensor, and wearable technologies. Efforts made to use smell in audiovisual media have faced a lot of challenges. This has experimented with a smell-enhanced screening of Iron man 3, the viewer was exhausted rather than fascinated by this new sensory simulation. Since there is hardly any knowledge base to know about people's previous multisensory experiences. As a result, there were links made between sensory stimulations and experiences. These experienced design has been of particular interest for museums and art galleries with a hope to engage audiences, convey the meaning, and to enhance the overall user-interactive components and dynamic displays, which has a strong influence on visitors experience, mainly in terms of the visitor's sense of flow and immersion.

5) **A Comparison of Scent-Delivery Devices and Their Meaningful Use for In-Car Olfactory Interaction (Published: 2017) [11]**

The proposal of a 3D framework to compare different scent-delivery devices based on the distance, volume, and speed of the scent-delivery. The use of olfactory stimulation has gained importance in the automotive context, for example, Yoshida et al. [12] developed a system to fight drowsiness while driving and has demonstrated in a study that releasing specific smells (peppermint, rosemary, eucalyptus, and lemon) could extend the wakefulness of the driver. While it was shown that both peppermint and cinnamon reduced frustration and helped participants to focus on the driving task, peppermint was also associated with faster reaction times.

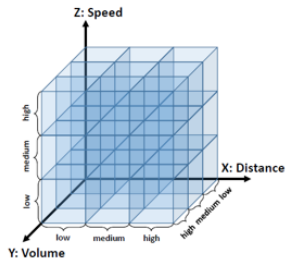

Fig 2: Three-dimensional comparison framework used to evaluate the X: Distance, Y: Volume, and Z: Speed of scent delivery demonstrated by four commercially available devices.

To extend this field further by using smell to convey information both to the driver and to the passengers (both co-driver and rear seat passengers). Examples for this could be: (i) the driver receives a scented notification of approaching a point of interest (e.g. gas station),(ii) the co-driver receives a smell for an interesting landmark recommended by Google Maps, (iii) rear-seat passengers receive different scents to enhance the interactive experience when watching movies or playing computer games. Since all devices are unique, we use this framework to compare the scent-delivery devices, using three dimensions: distance, volume, and speed of scent delivery [fig2]. The four commercially available scent-delivery devices are : (i) Vortex Activ USB
(ii) Scentee (iii) iPhone DUO3, and (iv) Aroma Shooter4 with each with characteristics.

	Scent-Delivery Devices: Manufacturer Specifications			
Characteristics	*Vortex Activ USB*	*Scentee*	*oPhone DUO*	*Aroma Shooter*
Scent cartridges	4	1	8	6
Scent combinations	16	0	>300000	64
Platforms	Windows	iOS	iOS	Windows/Linux/iOS
Interfaces	USB	Audio Output	Bluetooth	USB

Table 1: Comparison of four scent-delivery devices based on their key features.

Aroma Shooter for accurate scent delivery and fast reaction times. Scentee is suitable for mobile applications as it can be experienced on the move, where it is desirable to keep the scent-delivery within a personal space and not disturb surrounding people. which makes it opt for the co-driver, who can take the eyes away from the road and interact with a mobile device. iPhone DUO is suitable for the delivery of less urgent information but is less portable and currently only useful for desktop applications that can be integrated into the rear seat of the car. Finally, the Vortex Activ USB device is suitable for ambient uses, such as influencing the mood and emotions.

Key issues :

- The scent used must not cause allergic reactions.
- Every individual and culture have different considerations towards the smell is different. For instance, the scent of a root beer is considered pleasant in the US, whereas the same scent is associated with a strong disinfectant in the UK.
- The intra-subject variability in the olfactory perception.
- Due to the chemical molecules that compose each odourant. This chemical mixture makes it very difficult to reproduce, synthesize, and translate odours into digital information(bits).
- Olfactory stimuli occur and are integrated with other sensory stimuli affecting our experience depending on their congruency or incongruency with a situation.
- HCI has been used less in the field of education and training.
- When using olfoto the key issue would be getting hold of the smells to tagging photos.
- There should be appropriately customized cartridges like printer inks, to be dispensed by machines by digital photo kiosks.
- Sensorama faded away due to financial issues.
- When the smell is shared via the internet the participants were concerned with the alteration of the smell during transmission and misuse of smell.

Future research topics:

- The smell could be used in the field of education where children's in the pre-school can be taught about the name of different fruits and flowers by using smell-based technologies.
- In the scope of in-car interfaces, smells can be used as alarming or rewarding stimuli, to enhance the driving experience. Another big challenge involved not just delivering the scents but also removing it from the interiors of the car.
- Alongside improving the understanding of the sense of smell with their cross-sensory associations.
- Using smell for monitoring the health of elderly people and notifying their relatives about any emergency using notification messages.

- ➔ In the recent past, long-distance relationships are most common, with this scenario odours can be used to make perfumes which can help have an emotional connect with the person even though the person is physically not present.
- ➔ Since animals have a better sense of smell , dogs can be used to detect different forms of cancers and a device attached to its nostrils to check and analyze what cancer could smell like.

While placing an online order for food, if smell can be presented when a portion of food to order it clicked it might increase the online sales.

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