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Review Article

Aroma Tells a Thousand Pictures: Digital Scent Technology a New Chapter in IT Industry

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Abstract

The relevance of perception of smell and the corresponding olfactory communication changed, and attitudes of cultures towards olfaction differed through the ages. Finally enlightened philosophers declared odour and the sense of smell as immeasurable, unimportant and therefore unusable for scientific purpose. But, ironically, in the last few years more and more artistic multimedia installations used odours, scented products were sold and the increasing application of aroma therapy indicate a changed attitude towards social odours. Emotionalizing scents are largely used for influencing customers' behaviour in sales rooms and scientists are currently investigating the mystery of smell. The technological progress meanwhile allows for measuring and reproducing odours. Therefore odours are also becoming interesting for technical information transfer or communication, especially in Human-Computer Interaction. Smell seems to be an unrecognised medium and a new channel in multi-media. This paper presents various dimensions about olfaction and focuses on ongoing research and future challenges in digitizing smell and its transmission over internet.

Keywords: *Olfaction, media, odour, smell*

1. What Is Smell?

Olfaction, the sense of smell, is the ability to use the nose to notice or discover the presence of an odorous substance in the air, that is, an odorant - a chemical compound that has a smell or odour. It is estimated that humans can detect 10,000 to 100,000 different odorants. We also have the capability to distinguish between slight variations in the chemical structure of some odorants, as well as being able to detect the presence of infinitesimally small amounts of certain odorants, e.g. dilutions of less than one part in several billion parts of air. Thus, while our sense of smell may not be as acute as that of other mammals, e.g. sheep dogs, bloodhounds, it is still quite sensitive and remarkably acute (Ward, P., Davies, B. & Kooijman, D. 2007; Well&Good 2004). Till 1991, it was not understood how the recognition and perception of the 10,000 or so odours that mammals can detect actually worked and then Linda B. Buck and Richard Axel discovered the existence of a gene family in mammals which encodes olfactory receptor types and were awarded the Nobel Prize for their discovery (Gardiner, M.B. Fall 2004; Nobelprize.org, 2004). They discovered the presence of about 600 of these odorant receptor genes, with about a half of them being non-functional pseudo genes, thus leaving humans with approximately 350 olfactory receptor types. Discovering the presence of the odorant receptor genes and the role they play in odour recognition and perception of smells was the first clue in a puzzle that researchers had been trying to solve for a long while.

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Following this discovery, Buck and the rest of her research team then became preoccupied with solving the next part of the puzzle. They focused on finding out how it was possible for humans to have the ability to detect at least 10,000 different odorants with only 350 functional odorant receptor genes, and likewise for other mammals. Their research further revealed that the receptor types present in the olfactory receptor genes are used in a combinatorial manner to encode odour identities. That is, a single receptor is able to recognise multiple odorants, and a single odorant is recognised by multiple receptors, but that different odorants are recognised by different combinations of olfactory receptors. In this way, mappings of different combinations of odorant receptors create a vast array of different odour perceptions in mammals (Saltus, R., 2007; HHMI News, 2001).

2. Identification and Classification of Smells

Smell researchers were amazed that how it was possible for mammals to detect and perceive so many different smells, but for ordinary humans, the problem they face daily is what to name these different smells that they are able to detect. Research (Chastrette, M. 2002; Dubois, D. & Rouby, C. 2002; Kaye, J.N. 2001; Keller, A. & Vosshall, L.B. 2004) has shown that while we are often able to detect the presence of the variety of smells we come in to contact with daily, we are often unable to associate a meaningful name to these smells and will normally identify them by saying, "this/that smell reminds me of some *known* object", that is by association (Dubois, D. & Rouby, C. 2002; Kaye, J.N. 2001; Pines, M.).

Identification and naming of smells is a tedious job because to date there are no known standard classification schemes for smells. The most basic model of naming smells can be traced to the nature or the kind of feelings a particular smell evokes in one and the corresponding use of a synonym of 'smell'. For example, 'odour' and 'stench' are often used to describe unpleasant smells (e.g. body odour or the stench of urine); 'aroma' refers to pleasant strong smells usually from food or drink (e.g. the aroma of freshly baked bread or onions frying); 'essence' and 'fragrance' are sweet and pleasant smells such as perfumes; and 'scent' which is often used to describe natural smells or faint, barely perceptible smells such as the scent of flowers or the odour left in passing by which an animal or person may be traced. In literal contexts, the terms 'odour' and 'smell' are used interchangeably, however because odours are usually associated with unpleasant smells, 'smell' is the more general and neutral of these two terms, deriving connotation generally from the context in which it is used (Dictionary.com) ,or as Fox states in her article (Fox, K., 2007) ,'smells are guilty until proven innocent'. At a higher level, researchers have attempted to come up with classification schemes for identifying smells which has resulted in a number of proposed suggestions.

In one survey of odour classification schemes, Chastrette (Chastrette, M. 2002) identifies that generally odour classification schemes have been derived by using one of the following approaches:

- *Empirical Classifications*: based on the different feelings/experience odours invoke
- *Classifications Based on Primary Odours*: based on a small number of reference odours
- *Classifications Based on Statistical Methods*: based on using multidimensional statistical methods applied to large sets of olfactory data (in this work it refer to computer generated smell, i.e. smell output via devices controlled by computers.), including semantic descriptions of odours, odour profiles, and similarity data (ratings of similarities found between different odours).

The following were noted by Chastrette in the survey on odour classification schemes:

1) *There is a weak structure of the olfactory space*;
2) *The dimensionality of the olfactory space appears to be rather high with no clear explanations for the nature and significance of these dimensions*;
3) *A hierarchical structure was never observed*; and
4) *The multidimensional classifications confirm that classes of odours are not clearly delineated*.

Nonetheless, we mention some of the more popular classification schemes below. However, further detailed information with regards to odour classification schemes can be found in (*Olfactory Types*, 1996; Chastrette, M. 2002; Dubois, D. & Rouby, C. 2002; Kaye, J.N. 2001).
Examples of odour classification schemes based on primary odours include: the *Linnaeus*

Classification Scheme, a 7-category classification scheme made up of the following classes of primary odours: Aromatic, Fragrant, Ambrosial (Musky), Alliaceous (Garlicky), Hircine (Goaty), Repulsive and Nauseous. In this scheme, odour classes are based on a pleasantness scale, i.e. pleasant, unpleasant & pleasant for some and unpleasant for others (Chastrette, M. 2002, Kaye, J.N. 2001; *Carl Linnaeus (1707-1778))*.

Zwaardemaker Smell System, an extension to the Linnaeus classification scheme with the addition of two extra odour classes: Ethereal and Empyreumatic (burnt organic matter like roasted coffee or tobacco smoke) (Chastrette, M. 2002; Colman, A.M., 2001); *Hans Henning Smell Prism*, a classification scheme which identifies the following six primary odours: Flowery, Fruity, Resinous, Spicy, Foul and burnt, as the primary odours (Chastrette, M. 2002; Kaye, J.N. 2001; Colman, A.M., 2001).

Classifications based on statistical methods apply multidimensional methods to large sets of olfactory data, that is, classic semantic descriptions, descriptions emphasising similarities between odours and odour profiles featuring estimation of the intensity of each feature (Chastrette, M. 2002; Keller, A. & Vosshall, L.B. 2004; Callegari, P. Rouault, J. & Laffort, P. 1997). Semantic Descriptors are variables that describe chemical constituents of an odour, and in this approach, an odorous substance is described by means of a list of semantic descriptors, and the values of which can vary in intensity – that is, the approach estimates the distance between descriptors (Chastrette, M. 2002; Dubois, D. & Rouby, C. 2002; Keller, A. & Vosshall, L.B. 2004). Examples include Dravnieks *et al*. (1978) and Dravnieks (1985) list of 146 semantic descriptors, with intensity variations from 0 (descriptor absent) to 5 (descriptor strongly present) (Callegari, P., Rouault, J. & Laffort, P. 1997; Keller, A. & Vosshall, L.B. 2004); the 233 descriptors by Chastrette, Elmouaffek and Zakarya (1986); 126 odour descriptors by Abe *et al*. (1990) (Chastrette, M. 2002)

With odour profiles, an odorous substance is described in terms of a similarity profile that is related to a certain number of reference substances considered to represent as truly as possible the olfactory space (Callegari, P., Rouault, J. & Laffort, P. 1997). In this approach, a test odour is compared to mentally stored templates, i.e. list of semantic descriptors, with the semantic descriptors serving to rouse the subject's odour memory (Keller, A. & Vosshall, L.B. 2004) However, the problem with this approach is deciding on the choice of reference odours to base the profiling on. Nonetheless, a number of researchers have adopted this approach and simple examples include the Hans Henning model described above, as well as others described by Wright and Michels (1964), Amoore and Venstrom (1965), Boelens and Haring (1980), Jaubert *et al*. (1987) and Takagi (1987) (Callegari, P., Rouault, J. & Laffort, P. 1997; Chastrette, M. 2002).

Classification schemes based on descriptions emphasising similarities between odours uses an approach where the likeness between two odorous substances is ranked on a numerical scale fixed a priori (Callegari, P., Rouault, J. & Laffort, P. 1997). Panels of experts are usually involved in the ranking process involving the rating of similarities between all possible odorous pairs, and the odour under investigation is compared to reference odours and the perceived similarity between the odorants is used to describe the odour. Thus, say, if an odour is perceived as being more similar to a floral odorous substance than a musky substance, it is subsequently classed as belonging to the floral group of odours (Chastrette, M. 2002; Keller, A. & Vosshall). Researchers who have adopted this approach include Engen (1962), Schutz (1964), Yoshida (1964), Woskow (1968) Berglund *et al*. (1972), Dravnieks (1974) and Doving and Lange (1978), Coxon *et al*. (1978), Jaubert *et al*. (1987) and Lawless (1989) (Callegari, P., Rouault, J. & Laffort, P. 1997; Chastrette, M. 2002). Industry-based odour classification schemes are also quite common, and they are used to identify and describe the different classes of odours relevant to that industry. In the perfume industry, for instance, there is the Fragrance Wheel created by Michael Edwards in 1983 (Osborne, G., 2001). In the food industry, the taste of food can be altered by changing its smell, i.e. flavour, and as such a variety of flavour classification wheels to describe flavours for specific groups of consumable goods exists. Some known flavour wheels include: The Devil's Flavour Wheel, which describes bad flavours, The Beer Flavour Wheel, The Wine Flavour Wheel, The Coffee Flavour Wheel, Chocolate Aroma Wheel, Wheel of Cheese, Cornell University's Flavornet, Flavour Wheel for Maple Products (Kaye, J.N. 2001; Flavour Wheel for Maple Products; Flavour Wheels of the World, 2004; Flavour Wheel; Fragrances of the World).

3. Evolution of Artificial Production of Smell

The idea made its first widespread appearance with the 1960 film Scent of Mystery, which timed odours to specific points in the narrative. The film opened in three specially equipped theatres in New York City, Los Angeles, and Chicago. Unfortunately, the mechanism did not work properly and audience members complained of a hissing noise accompanying the scents - as well as a delay between the actions and their corresponding smells. As a result the film failed miserably, even after the mechanism was fixed.

Smell-o-vision has been on the tech industry's radar for what seems like forever now, and made its first widespread appearance over 50 years ago in the conveniently titled 1960 film Scent of Mystery. However, there are documented cases of scents being used in conjunction with theatre dating back to over 100 years ago. Cotton was soaked in rose oil, and then placed in front of a fan in order to waft the scent around. A bit of cotton soaked in one specific oil isn't dynamic, though, and can't change scents based on what is happening on-screen. Fortunately, this isn't difficult to overcome. A typical smell-o-vision machine is essentially a box of various scented oils with some kind of spreading mechanism, like a fan. The box receives a signal from, for example, a video game, which tells the box to release an ocean scent. Like a box of crayons, if you don't have the exact colour you want, you can just mix some of the ones that are available. So, if single ocean-scented oil isn't available, other oils would mix to create something close to that desired ocean scent.

Fig. 1

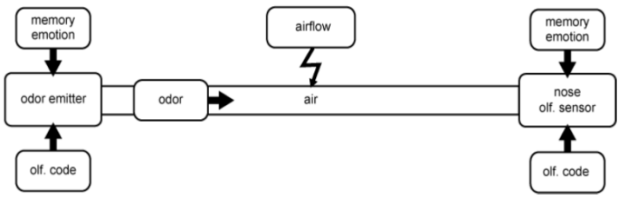
The brains of "smell-o-vision"- Michael Todd Jr. (left) sits beside master control and scent energizer of the Smell-o-vision system with its inventor Hans Lube. Latter points to the multitude of vials each containing a different scent which is selectively projected through tubes to every seat in theatre on signal triggered from picture's sound track.

Nearly two centuries later, however, in the 1970s, the Swiss fragrance chemist Roman Kaiser developed the odour-preservation technique he dubbed headspace capture a process meant to analyze and manufacturer the fragrances of the natural world. Kaiser used his technique to measure and then recreates the scents of a tropical rainforest; scientists and perfumers have since adapted the process, however, to recreate scents of a more quotidian variety.

In the 1980s, the scent scientist Braja Mookherjee, working for the fragrance firm IFF, invented a process that allowed technicians to extract fragrant molecules from living flowers, with the ultimate goal of recreating their smells. In the late 1990s, Japanese scientists began developing an "odour recorder" that promised to capture and replicate the world's scents. Today, the odour artist Sissel Tolas uses headspace technology to create "scratch and sniff" maps of the world. Olivia Alice uses a similar technique to preserve the scents of loved ones that linger on their clothes — by "deconstructing the clothing and extracting its composite and essential elements" (CH.ARAVINDA *et al)*

4. Smell as Media

Smells have always conveyed information, from warnings – burning, damp, gas – to more positive scents – cooking, wine, perfumes. Olfactory information offers new possibilities to Human-Computer Interaction (HCI). In the last few years information engineers undertook first steps using odour as interface between user and computer. Gas sensors, artificial noses and digitally controlled scent diffusers allow the digitalization of olfactory information and reproduction of odours. The progressive development of such olfactory technology demonstrates the existence of an olfactory medium, also in a technological manner, which takes its place in the real as well as the virtual world. The following is Shannon-Weaver Model for olfactory communication (Weaver, Warren/Claude E. Shannon, 1949).



The basic theory behind the model is that, odour can bear information like emotions, warnings, memories but also genetic information as body odour or pheromones. Therefore odour is media-theoretically definable as a medium. According to Shannon's (more technical) information theory air would be the medium and odour the message. He said that each message needs syntax, semantic and pragmatic, in one word: a language, which is spoken by sender and receiver. Relating to the odour as medium – which means that odour transmits additional information (e.g. the odour of smoke transmits the in-formation, that there is something burning) – there is no unique olfactory language. Syntax, semantic and pragmatic is defined by culture and individual experience, but also by profession. Perfumers, sommeliers or food designers have their own language within their community. Also some indigenous peoples have their own olfactory language. However, all others have forgotten that we can smell and consciously communicate via smells. We use odours every day, but not deliberately.

We are giving special emphasis on this, because, the last hundred years have seen a variety of experiments combining smell with other media.

We are enumerating some conjunctions of odour with various media forms.

4.1 In Museums

Exhibitions in museums are being accompanied by smell which creates an everlasting effect on spectators. A very interesting approach is taken at the Jorvik Viking Museum in York, England, in which Viking-appropriate smells were piped into exhibits; a process that researchers found aided remembering the information shown in the exhibit. (Aggleton, J.P., Waskett, L., 1999). This study is a very interesting example of the use of smell in comparatively informal education, and we think it has some interesting applications when implemented in a virtual medium.

4.2 In Theatres

Roman theatres were often richly scented with saffron or other scents; amphitheatres had fountains spray scent into the air. The perfumes helped mask the many unpleasant odours arising from the entertainment of the time: not just the smell of the crowd, but the blood of wild animals spilt on the sand or of burning flesh. (Classen, C.,Howes, D. ,Synnott,A, 1994).

Use in theatre in more recent times has been rarer. The role of smell in a performance is generally to increase the immersive effect of the experience, to encourage the audience to accept on a deeper level the events that occur onstage. There is, however, a problem: audiences can be brought out of the scene by the novelty of scent, commenting on it, rather than being further immersed as desired.

The German choreographer Pina Bausch's 1982 show *Nelken* involved the scent of carnations wafting out into the audience. Moses Pendleton's 1985 ballet *Baseball* had the aroma of fried onions and marijuana wafting out into the audience, with the intention of setting the scene for a baseball match. 1988 saw English National Opera staged a production of *Love for Three Oranges* where audiences were provided with Scratch-n-Sniff3 cards. The opera was later televised, and the BBC-run *Radio Times* magazine included cards for the home audience to smell while watching.

4.3 In Films

Smell has probably been most explored as an experiential medium in conjunction with film. 1906 saw the first documented use of smell in conjunction with movies, when a Pennsylvania cinema owner added the scent of roses to a screening of the Rose Bowl football game. (Longino, Bob, December 5 1999) AromaRama was the first attempt at combining smell and film, relying on industrial perfumes being wafted through the cinema's ventilation system: it arrived in 1959 with *Behind the Great Wall* and was quickly forgotten. 1960 saw the introduction of Smell-O-Vision, piping scents directly to the seat of each viewer (Fig. 1). Critics were not impressed: one New York Times review began with the phrase 'If there is anything of lasting value to be learned from Michael Todd Jr.'s 'Scent of Mystery', it is that motion pictures and synthetic smells do not mix.' (Time Magazine 21 December 1959, p57.) John Waters was the next director to attempt the use of smell, with deliberately kitsch scratch-n-sniff cards handed out to the audience for his 1981 film *Polyester*, a technique also used by the Independent Cable Network in 1999 who sent viewers 'decoder cards' for a special edition of the animated series *Cow and Chicken (*Lefcowitz, E. 1999*)* It is important to distinguish between the immersive nature of the preceding smell devices and the dissociative relationship of Scratch-n-Sniff cards to their accompanying media. These technologies have gone to the graveyard of dead media, remaining one-off novelties. We feel it is significant that despite the fact that both AromaRama and Smell-O-Vision flopped after a single movie, the technology has stuck deep in the popular memory. Understanding how and why they flopped, is important in looking at the future of smell and computers.

4.4 In Computers

There is a small amount of prior work on using smells with computers. Most notable is Morton Heilig's device, 'Sensorama', patented in 1962 (Heilig, M. L. Experience Theatre) – and brought back to the attention of the public by Rheingold in 1991(Rheingold, Howard 1991). Sensorama looked like an arcade game and gave the user the experience of a ride through Brooklyn (Fig. 2): the feeling of rattling over the cobblestones, of going around corners on a motorbike, the sounds of children playing and the smell of an Italian pizza shop as one passed by. Sensorama never received the funding it needed to scale up to beyond the near prototype level, and the technology quietly passed away. There is some work on smell in virtual reality, although perhaps less than one might expect. Much of it has concentrated on the field of fire fighter training (Cater, J.P), where smell gives valuable and potentially life-saving information about what is on fire.

Fig. 2

There appear to be a few other research efforts looking at implementing smell in virtual reality, but they seem to be limited in scope (Zybura, M., and Eskeland, G. 1991).There has been some work in wearable aroma-producing applications, by Jenny Tillotson. These are currently limited to demonstration models, but we see potential for wearable applications, particularly as both wearable computing and dynamic aroma generation become more common. There is a notable absence of use of smell in the ambient media literature, which we feel is strange, given that smell is such a perfect ambient media: it can move easily from our periphery to the centre of attention and back out again. (Ishii, H., *et al*. April 18-23, 1998; Wisneski, C. A. April 18-23, 1998) Strong & Gaver's 1996 short paper 'Feather, Scent, and Shaker' looks at the possibility of a single device that produces scent so that one party knows what another is thinking of them. The piece leverages smell's quality of 'lingering like a memory' (Strong, R. and Gaver, B. Feather, Scent and Shaker. 1996).

5. Digitization of Smell

The first commercially available air design systems could not adjust running time, fragrance or scent volume; they continuously run and lead to an "aroma flood".

This leads to digitization of smell. Dexster Smith and Joel Lloyd Bellenson, experts in bioinformatics and genomics, started from the following idea: "If we can find the essence of a biological smell and build a profile, we can digitalize and broadcast it." Based on this principle only, modern systems offer an adjustment of time and volume as well as changing between various fragrances.

The **digital smell** is basically a hardware software combination. The hardware part of digital smell will produce the smell, and the software part will evaluate the smell equation and generate specific signals for specific smell and finally that smell will be produced by the device. The hardware device is a device like speaker, like speaker this device is also connected to the computer system. For this device there is also a driver program which will evaluate the digital equation for generating specific gas.

Today digitally controlled odour diffusers are not only applied for advertising purpose, they are also developed as ambient indicators like an olfactory display for Human Computer Interactions-systems (Figure 7). For instance, Keye reported on an ambient olfactory reminder system. DigiScents, an interactive media company, created iSmell Digital Scent Technology, with an aim to broadcast scents over internet (Science, Technology & Innovation Studies). An integration of an augmented reality application with an odour ma-chine to improve on the augmented reality experience is presented in Emsenhuber *et al*. 2002.

NTT Communications (2007) have developed a smell machine called *Aroma Geur*, laying the path to the first olfactory emails in 2004. This device was also used to create an ambient smell when listening to Tokio FM. In 2005 TriSenx (2005) launched their *Scent-Dome* to enable websites emitting scents. The only system which reached the maturity phase and can be bought now is the Osmooze Personal Diffuser.

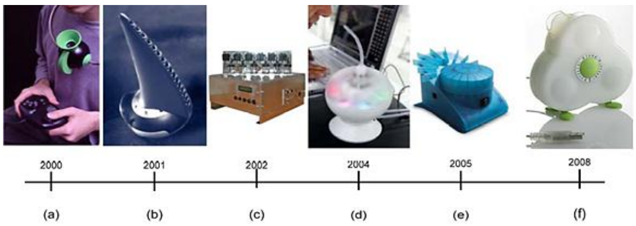


Fig : a. AromaJet Pinoke, b. DigiScent iSmell, c. FH Hagenberg SmellBox, d. NTT Com Aroma Geur, e. TriSenx Scent Dome, f. Osmooze Personal Diffuser

Meanwhile, telecommunication industries have also found the olfactory information channel to be a useful medium and are marketing the first scenting mobile phones (cf. Motorola 2007; Softpedia 2007). The special smoothness of olfactory interaction spaces was the central subject of the *Space-of-Scent*-project realized by Haque Design & Research (2002). For telecommunication industry smell has been successfully introduced as a new sensory modality for interactions between human and mobile devices The first "smelling" mobile phones were placed on the market in 2008 (Science, Technology & Innovation Studies).The Sony Ericsson SO701i is scented with an aroma therapy fragrance to support relaxing during stressful phone calls. To satisfy different preferences the mobile phone is available with eight different fragrances, which can also be useful for advertising purpose and tagging personal things like mobile phones with corporate scents. Also Hyundai (2005), Samsung (2006) and Motorola (2007) have developed such mobile phones. German inventors have already patented a mobile phone with a smell chip which allows sending and receiving *smell messages* (Science, Technology & Innovation Studies).

6. Various Researches Using Olfaction and Olfactory Data

6.1 Neurodegenerative Disease Diagnostics using digital olfactometer **(**Donald J. Hayes, David B. Wallace, David Taylor, Bogdan V. Antohe, Ioan Achiriloaie, and Norman Comparini. Nov.11-12, 2007**)**

This olfactory threshold testing was conducted in the Human Performance Laboratory at Presbyterian Hospital of Dallas, Texas in a well-ventilated room.

The testing methodology is as follows. For each trial within a test, subject was exposed to digital olfactometer device and discrete levels of odorants were presented to the subject's nose who was then asked to sniff on verbal cue and then provide a suitable response: "yes" (odorant detected) or "no" (odorant not detected). The test administrator interpreted the subject's responses and then adjusted the control stimulus intensity (number of drops) up or down depending on the subject's current and previous responses. The response of an infected subject is compared to a response of normal subject and findings showed that diseased subject were not able to detect smell whereas others were, and there was a remarkable difference in the response of two groups.

The neurodegenerative diseases like Alzheimer's and Parkinson's are increasing day by day.

Early diagnosis coupled with interventions that could delay the onset of the disease or slow down its progress would significantly aid the caregivers and reduce the cost of care. Studies indicated that, in its initial stages, Alzheimer's disease attacks medial temporal lobe structures that are critical in smell identification. As the disease progresses, further deficits appear in the patient's ability to identify and detect odours and the patient becomes unaware of the deficit. A method capable of quantifying the patients' olfactory capability will not only facilitate early diagnosis of neurodegenerative diseases like Alzheimer's or Parkinson's, but will also provide the means to track the progression of the disease.

6.2 Development of a Perfume Emission System via Internet **(**J. Comput**)**

Fig Picture of perfume emitting device connected to a PC developed at Fukui National College of Technology

Yoshimura and Sakashita developed a "perfume emission system via internet" at Fukui National College of Technology, Japan. In their experiment they developed a USB interface device for emitting the perfume. Various perfume components were stored in the perfume emitter. The perfume was emitted, when the mail with the key program of the perfume emission was read via Internet.

The perfume emitter device was connected to personal computer through a universal serial bus (USB) port. It can be plugged into any ordinary electrical outlet. Once the user requests the perfume odour, the digitized perfume data are sent to the perfume emitter device, which then emits the odour into the user's immediate area. The device emits natural vapours triggered by a mouse click of the mail icon.

6.3 Smelling Screen (Ch.Aravinda et al)

A team from Tokyo University of Agriculture and Technology in Japan have invented a 'smelling screen' that makes smells waft from the spot on a display that their corresponding objects appear. Created by Haruka Matsukura and a team of colleagues at Tokyo University of Agriculture and Technology, the display is called the "smelling screen," and dispenses with the need for an extra box full of oil. As New Scientist points out, the display is a standard LCD, but has an air stream in each corner of the screen. From those screen corners, gel pellets are vaporized and sent into the air streams, which are then sent out to the specific portions of the screen via fans. The power and direction of the fans are efficient enough to send, for example, the smell of fried chicken to the drumstick displayed at the bottom of the screen. Currently, the smell-o-system can only produce one scent at a time, but the team aims to create interchangeable cartridges so you can easily swap out which smells you want your display to produce.

6.4 Olfaction-Enhanced Multimedia

At Brunell University researchers designed a multimedia presentation display program, which displays visual and audio media content from video clips synchronized with olfactory data (described in Table 1). The smell generating device they used was Vortex Active scent dispensing system by Dale Air. It is a personal computer smell dispensing system which uses miniature fans to propel the emitted smells in the right direction and it connects to the computer via a USB port. The device is supplied with a USB fan controller API that is used to manage the release of olfactory data.

Table 1

Smell Category	Burnt	Flowery	Fruity	Foul	Resinous	Spicy
Video Description	Documentary on bush fires in Oklahoma	News broadcast featuring perfume launch	Documentary about rotting fruits	Cookery show on how to make a fruit cocktail	Documentary on Spring allergies & cedar wood	Cookery show on how to make chicken curry
Smell Used	Burning Wood	Wallflower	Strawberry	Rancid Acrid	Cedar Wood	Curry

They integrated this API with their multimedia presentation display program to control the synchronized release of olfactory data during each video playback. The smells used in their research were selected from the six smell categories; Burnt, Flowery, Fruity, Foul, Resinous and Spicy, described by Hans Henning. Based on their findings, they claimed that users were enthralled by the olfaction enhanced media and they recorded many suggestions from the users for further enrichment of the process.

6.5 Detecting heart diseases using electronic nose (www.webmd.com; www.cnet.com)

A team of scientists at the University Hospital Jena is testing an electronic nose system that's able to distinguish between people without heart failure and people with it, and even between two types of heart failure (compensated and decompensated) with almost 90 percent accuracy--higher than what canines were able to achieve in the lung cancer study.

The system includes three thick-film metal oxide-based gas sensors with heater elements. Each is tailored to sense different odorant molecular types. As oxygen reacts to the heated sensor surface, the molecules interact with the sensors and change the free charge carrier concentrations, and thus conductivity, in the metal oxide layer.

Having already collected the relevant parameters for heart failure (BNP, creatinine, clinical history, etc.) in 126 patients in 2010, physicians blinded to those results then used the electronic nose to assign the patients to one of three groups: no heart failure, and then two types of chronic heart failure--compensated (a condition where treatment is able to compensate for the failure) and decompensated (where treatment is not working, and can be caused by arrhythmias, infections, electrolyte disturbances, etc.).

The sensor was simply placed on the arm much like a blood pressure monitor for three minutes at a time and then analyzed for heart failure markers. It was able to distinguish between patients without heart failure (the control group) and patients with heart failure with almost 90 percent accuracy, and then to divide patients with decompensated heart failure from those with compensated heart failure with almost 90 percent accuracy.

The team, which says more research is required to identify the responsible components, presented its findings over the weekend at the ESC Congress 2011in France. Ultimately, the scientists hope to create a minimally invasive method to help rapidly screen, diagnose, group and monitor compensated heart failure.

6.6 Urine Odour Can Detect Bladder Cancer, Study Shows (www.bbc.com)

The urine odour test could detect whether a patient is suffering from bladder cancer or not according to the latest study published in the journal of PLOs One. Some specific types of chemical are released by patients with balder cancer in urine in the gaseous form that can be easily detected by using a sensor that can detect these chemicals. During the initial trials researchers have found optimized accuracy but more research and study is needed as suggested by the researchers.

It is estimated that approximately 10,000 people in the UK are being diagnosed with bladder cancer in each year. Researchers are attempting to discover new techniques to detect balder cancer at an early stage which can facilitate doctors regarding its treatment.

It has already been discovered during the previous studies that some types of cancers can be easily detected by using dogs that can determine a particular odour of cancer.

This newly discovered device is fully equipped to determine cancer smell as said by Prof Chris Probert, from Liverpool University, and Prof. Norman Ratcliffe, of the University of the West of England. “It reads the gases that chemicals in the urine can give off when the sample is heated,” said Prof. Ratcliffe. During this study researchers evaluated 98 urine samples, 24 from men who were diagnosed with bladder cancer and 74 from men who have some sign and symptoms related to bladder cancer but they were not suffering from bladder cancer.

Prof. Probert said the results were very encouraging but added: “We now need to look at larger samples of patients to test the device further before it can be used in hospitals.”

Dr. Sarah Hazell, senior science communication officer at Cancer Research UK, said: “It would be great to be able to detect the ‘smell’ of cancer in a robust and practical way but, promising though this work is, we’re not there yet.

“This latest method is still at an early stage of development, and needs to be tried out on a much larger set of samples, including samples from both women and men.

“The researchers say that the test would be around 96% accurate in practice and their findings are only based on a relatively small number of samples, taken only from men. But it is another promising step towards detecting bladder cancer from urine samples, something that would ultimately provide a less invasive means of diagnosing the disease.”

6.7 The oPhone (edition.cnn.com)

Dr. David Edwards, biomedical engineer at Harvard and founder of Le Laboratoire, known for producing radical sensory devices such as calorie-free chocolate spray is now ready to launch its new invention “oPhone” (in July 2014) which offers the most sophisticated smell messaging yet created.

Harvard professor and oNote co-inventor David Edwards shares the scent with a member of the audience.

In collaboration with Paris perfumers Givaudan and Baristas Cafe Costume, Edwards has created a menu of scents, contained in 'oCchips'. MIT electrical engineer Eyal Shahar designed containers for them that release when heated by the touch of a button, but cool quickly to keep smells distinct and localized, a historic difficulty with the much-mocked smell-o-vision experiments in cinema.

The oPhone user can mix and match aromas and then send their composition as a message, which will be recreated on a fellow user's device. Up to 356 combinations will be possible in the first wave, rising to several thousand in the next year, and the dream is an exhaustive base -- the 'universal chip'.

"Biologically we respond powerfully to aroma, so if we become familiar with the design of aromatic communication we might be able to say things we couldn't before", says Edwards. He sees the limited aromas of the oPhone as the first letters of a rich new language that may be used as a basis for novels and symphonies. The faith is grounded on the acknowledged influence of smell on the subconscious, and the potential to learn its secrets.

6.8 Healthy aroma (edition.cnn.com)

Monell Chemical Senses Centre is also pursuing the goal of digitizing olfaction, with healthcare applications high on the agenda. One of their research areas is seeking smell biomarkers in cancer patients, using an 'e-nose' to hunt chemicals in the blood to deliver early diagnosis. The process was inspired by the ability of dogs to sense sickness, although their smelling ability is multiples higher.

Although this research is still young in the lab, similar technology is already being smart phone-enabled. NASA-developed a chemical sensor has been released to a commercial partner as the basis for mobile applications that could breath-test users. UK Nanotechnology Company Owlstone is raising several million dollars in venture capital for a handheld sensor that that could detect a wider range of diseases.

Medical uses are high on the agenda for the burgeoning Digital Olfaction Society, whose upcoming conference will discuss olfaction technology for identifying dangerous gases, guidance for the blind and cognitive aid for Alzheimer's sufferers. But industries as varied as military, travel, jewellery, food and entertainment will also be represented.

7. Disasters that could have been prevented (Wikipedia sources)

7.1 The Bhopal disaster: Also referred to as the Bhopal gas tragedy, was a gas leak accident in India, considered the world's worst industrial disaster.It occurred on the night of 2–3 December 1984 at the Union Carbide India Limited (UCIL) pesticide plant in Bhopal, Madhya Pradesh. Over 500,000 people were exposed to methyl isocyanate (MIC) gas and other chemicals. The toxic substance made its way in and around the shanty towns located near the plant.

In this disaster about 30 metric tons of methyl isocyanate (MIC) escaped from the tank into the atmosphere in 45 to 60 minutes. This mishap could have been prevented if some odour detecting sensor or an electric nose were installed in the industries. MIC has a very irritating and pungent odour and hence could have been easily detected.

Henceforth, all other industrial setup which uses hazardous material as inputs/outputs or excrete them as waste products must shift over to odour sensing gadgets in order to avoid mishaps and tragedies.

7.2 The New London School explosion: Occurred on March 18, 1937, when a natural gas leak caused an explosion, destroying the London School of New London, Texas, a community in Rusk County previously known as "London". The disaster killed more than 295 students and teachers, making it the deadliest school disaster in American history. As of 2014, the event is the third deadliest disaster in the history of Texas, after the Galveston Hurricane of 1900, and the 1947 Texas City Disaster. Same story applies here a simple olfactometer could have saved life of many young innocent children and their teachers.

8. Disasters that can be prevented

In India gas is supplied to homes in cylinders. Many cases of gas leaks from cylinders have been reported and hence, some serious steps have to be taken else another catastrophe would be witnessed. One way that we are suggesting is that, every cylinder must be accompanied with an electronic device which would consist of an olfactometer and a nozzle. After detecting the odour, above a predefined threshold, cylinders would automatically be sealed by that device and further leakage would be stopped. Same is applicable to automobiles for detection of fuel spillage.

9. Some Bigger Challenges

Some users may be temporarily or permanently, are unable to receive smell information – having a cold, or anosmia. Also, the slow refresh rate of smell can be a problem, such as the smell of grass in the desert above. Furthermore, differentiating different smells can be hard: if two smells are already in a room, it’s hard to determine the presence of the third or fourth. There is also the problem of dispersal. Office cubicles are currently designed with the express purpose of controlling the dissemination of video and audio. [49] Smell, on the other hand, spreads: you may be aware when the co-worker next to you is drinking coffee. As such, smell is perhaps more useful in a context where enveloping the user to give a total experience is more important than privacy of information. Furthermore, there is currently no directionality in smell production. Fundamentally, we do not yet understand what the users’ expectations of smell as a medium will be.

Conclusion

We feel that there is a great deal of potential for the use of smell in Human Computer Interaction and as an output medium; however, it is a medium with the potential to be extremely intrusive, and care must be taken to avoid gratuitous. In present scenario various dimensions of odour are being tested and explored; in health, in entertainment, as education facilitator and especially as medium. This pace of research must increase at an exploding rate as research in smell is infinitesimally small as compared to research in other areas of audio, video and image processing.

We are enumerating a set of key problems that must be addressed in exploring the role of smell as a medium. The problems that the New York Times identified in their review of the 1960 Smell-O-Vision premiere *Behind the Great Wall* (Time Magazine, 21 December 1959, p57.) remains relevant and applicable to those addressing smell as media today. We reiterate:

'To begin with, most of the production's 31 odours will probably seem phoney, even to the average uneducated nose. A beautiful old pine grove in Peking, for instance, smells rather like a subway rest room on disinfectant day. Besides, the odours are strong enough to give a bloodhound a headache. What is more, the smells are not always removed as rapidly as the scene requires: at one point, the audience distinctly smells grass in the middle of the Gobi desert.'

These four problems of smell accuracy, intensity, duration and directionality are the key areas that must be addressed for automatic smell devices to become an accepted and viable technology.

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