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Anaglyph video smell presentation using micro-porous piezoelectric film olfactory display

Saad Hameed Abid [a,b,*], Zhiyong Li [a], Renfa Li [a], Jumana Waleed [c]

[a] College of Information Science and Engineering, Hunan University, Lusan Southern Avenue, Yuelu District, Changsha, Hunan 410082, China
[b] AL-Mansour University College, Al-Andalus Square, Baghdad, Iraq
[c] School of Information Science and Engineering, Central South University, Changsha 410083, China

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ABSTRACT

Anaglyph video (i.e., 3D video) is a recent trend in movies and multimedia; the method has also been recently developed for conversion of such videos from traditional 2D screens or by rendering stereoscopic media into 3D video. There have also been many studies regarding movie playing and other types of entertainment that uses olfactory displays or smell generators. These devices are capable of generating a considerable number of different odors with different intensities yet still have some limitations and are not ready for commercial use. In this study, a complete solution is presented for a user to experience olfactory sensations with a displayed video on a PC with auditory and 3D visual effects using a novel olfactory display device based on a micro-porous piezoelectric film that is capable of digitally producing fine particles of scent material with precision, quantity and speed.

1. Introduction

Many studies have investigated olfactory displays but have focused on building the display itself and the associated implications and challenges that might arise; others have introduced a novel approaches of smell generation and delivery using a piezoelectric transducer film with a fine mesh to generate a droplet that can be controlled digitally, providing a discrete (i.e., digital) amount of smell. This allowed the smell to travel from the container holding the smell to the nose of the user in a minimum time on the order of a second or less.

2. Related works

There are many studies in the literature in the field of olfactory displays that use different technologies to provide a better and fast delivery of scent material to the user. These attempts have had good results yet are incomplete and have certain drawbacks. The problems arise from successfully building a scent-providing element that is capable of transforming the scented material state, which is primarily liquid, to a state can be intercepted by human olfactory sense (i.e., air borne molecules). Another problem is providing a robust mechanism to digitize the concentration of the scented material. Additionally, the response time must be sufficient to the desired application considering the human olfactory system's response to the projected scent. It is important to state that these attempts have been considered as the foundation of olfactory displays. In [1,2], a projection device was proposed to eject scent based on a nose tracking feature; this ejection was accomplished using an air cannon that contracts when scent delivery is desired; the scent is delivered inside the cannon and ejected. These systems in their final improved prototype provided minimal amount of scent material by injecting scented air so that the scent is diffused quickly after it is presented it minimized the level of residual scent after it suffered from residual scent problem in their early prototypes but still inherited all the problems of scented air delivery which requires an external air pump and a number of electromagnetic valves as stated by the author in the final third version, four scent inputs each one controlled with two valves and one air input valve in addition to fresh air input valve which are in total 10 valves. In addition a pan and tilt motors are used to direct the air cannon and a motor to drive the bellow for ejection impact. All these components requires significant amount of power for all prototypes hindering its evolution for a standalone computer powered equipment. Finally it is obvious that the residual scent in the system is high for early prototypes and where reduced significantly in the final prototype after improving the delivery mechanism but still required an external air supply equipment.

* Corresponding author at: College of Information Science and Engineering, Hunan University, Lusan Southern Avenue, Yuelu District, Changsha, Hunan 410082, China.

E-mail address: saad@hnu.edu.cn (S.H. Abid).

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This technique is focused on scent delivery and spatial control technique, which is almost independent of scent generation techniques. In [3–5], the same olfactory display was used to disperse scented material toward the user using solenoids valves and an air compressor to create airflow. This concept is based on bubbling air into the liquid scented material to create an evaporated scent mixed with air (i.e., an airborne scent) and controlling the flow of that air/scent mixture among other types of scents produced in the same way to be directed to the user's nose. Because solenoids are electromagnetic devices with mechanical movements, they require a significant amount of energy while operating. The authors used a 3-way rapidly switching solenoid valves which these electromagnet components draws at least 200 mA, yet they are a little bit quiet and produce almost no sound according to author's claim; an air pump must also be used to provide airflow to the olfactory display. The author used (Contec, PIO-48D (CB) H) obsolete (according to manufacturer) control card it has only handle 8 mA via each pin, therefore the author used a transistor amplification circuit for each solenoid valve (used 32) hence there are 32 solenoid valves. Also the author stated that it requires some labor to change the scent component which diminishes the interchangeable cartridge property which the author recommends and the proposed system contains such feature. It is fair to say that even the display was in basic in design and have some drawbacks but still the authors provided a paved roadmap to others to follow their steps in olfactory displays design. Refs. [6–8], another approach was applied that used an electro-osmotic micro pump to deliver a predefined amount of scented material to be dispersed using a surface acoustic wave (SAW) device that is capable of producing a vapor rapidly; however, the hardware setup needed voltage levels as high as 100 V for the driving circuit but produced the vapor instantaneously and efficiently. Other techniques such as [9] used a solid/gel scent material and a Peltier module; the module produced heat to transform the solid/gel material into vapor and deliver it to the user. Such systems require a high current supply to heat the Peltier module to a sufficient evaporation temperature; the time required to achieve such a temperature is also typically relatively high. Using this technique, olfactory display devices have been limited to desktop systems connected to a personal computer and other supportive devices, such as high current supply, air pump and frequency generators. In [10–12], olfactory displays were worn by the user, and the scent ejection point is placed near the user's nose. This approach is suitable for virtual reality applications when the user is mobile rather than sitting at a desk. This technique solved some problems of scent delivery but still has limitations in terms of intensity control. In [13], a more precise technique is used based on inkjet cartridge technology, where an ink cartridge was modified to eject liquid scent rather than ink using the same principles of ink level control, mixture and evaporation. In [14], a more advanced model of olfactory display was included in a real-world application of sensing smell in a certain device and sending primitive olfactory data merged with a captured image through an ADSL connection via the Internet. Nakamoto et al. have produced the most mature studies in the field of olfactory displays, but the smell projection device they used is based on [4,5]. Hirose et al. introduced many head-mounted olfactory displays, including a scent generation and blending mechanism that was controlled by computer [15,16]; they also recently developed

Table 1
Comparison between the proposed scent element and popular olfactory displays.

Reference No.	Type	Delivery response time (Speed)	Residual scent material	Noise level	Power consumption	Number scent of types	Levels of intensity	Limitations
[1,2]	Air cannon with air compressor	High	High for prototype 1 and 2 low for final prototype	Medium	High	4	1	This technique is focused on scent delivery and spatial control technique regardless of hardware limitation of power consumption. Yet still consumes significant amount of power due to the usage of numerous motors, actuators, air pump and valves
[3–5]	Solenoid valves and air compressor	Medium	High	High	High	32	1	Lab environment only, requires high power due to usage of 32 solenoid valves (200 mA each), PIO-48D (CB)H control card (120 mA), Driving transistor for each solenoid (2–5 mA), a flow fan (500 mA) and (Iwaki, APN-215NV-1) air compressor (1 A) yielding a total current higher than others. The author manually changed scent concentration in the bottles to obtain different intensities
[6–8]	Electro-osmotic micro pump and SAW atomizer	High	Low	Very low	Low	6	5	Lab environment only, high voltage for SAW device
[9]	Solid scent material with Peltier module	Low	Medium	Very low	High	15	1	Heating takes very long time and consumes high current around 1.2 A for each card
[10–12]	User worn with air pump	Medium	Medium	Low	High	3	1–128	Relatively Heavy equipment always carried by the user and consumes high power. The author used three Enomoto Micro Pump Mfg.Co., CM-15, each weighs 60 g requires 0.4 A current, head set, tubes, metal casing circuit boards all about ≅300 g, as a control unit used a PC laptop ≅4000 g, RFID tag reader and casing ≅200 g
[13]	Inkjet	High	Very low	Very low	Medium	1	0–255	Heating the scented material causes scent deformation
Proposed	Micro-porous piezoelectric film	High	Very low	Very low	Low	6	6	Low noise <18 dB, no heating, low current 400 mA, low voltage 5–12 V, ejection can be done with intervals as short as 200 ms and 200 ms apart from ejection till detection and weighs 377 g in total (no scent material)