Smelling the Web Olfactory Display for Web Objects

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Abstract: *Internet technology has gone a very far in term of advances and improvements, flash players, video components and other multimedia support are incorporated into the recent web pages. Also, services provided such as*: *Clouding, storage system, online banking and e-commerce are very common and used on daily basis, still there are many missing components regarding more human interaction with the web page, rather than just seeing and clicking. In this paper, we implemented a system that's capable of identifying mouse location onto a web page and capturing that component (mostly images) extracting its meta-data and Exchangeable Image File Format (EXIF) information, this information is processed further by a basic natural language processing subsystem providing it with text parsing results after tokenizing the string, this is to come with a single conclusion*: *What dose this image represents. The result is normally a single descriptive word corresponds to that image sent to a micro-controller to be analyzed through a table with corresponding values essentially a set of pulses and signals data, to display it as a smell corresponds to the item under the mouse by applying the pulses to the atomizer to give the user the smell of that object. We found that the system has high successful identification ratio over websites with fairly accurate image identification ratio.*

Keywords: *Olfactory displays, web-smell, web object, scent, atomization.*

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1. Introduction

Many attempts are made to implement olfactory displays, some of the attempt's are professional and done by companies and other are individual attempts yet still no commercial product that is fully operational and functional for the end user, there are many problems and challenges arises such as electronically and chemically in addition of technological that make such system not easy to implement.

our system is a tradeoff between most of the solutions and problem to make it possible to build and implement such system even by a user with substantial skills, the system is basically a web content smell generator that helps the user to "smell" the contents of the web such as images with certain contents, with some standards applied by the companies it can be used as an e-commerce tool to smell the aromatic items such as perfumes, soaps, deodorants, flowers etc., prior to purchase.

The system connects to the events of the currently active instant of Internet Explorer (IE) and intercepts events of mouse movement over the picture objects and captures its file name then analyze the picture and perform a corresponding aromatic generation on the output device, of course this feature can be activated/deactivated by users choice so the user can surf the internet with or without smell generation.

2. Related Works

An early approach that incorporated smell using a PC controlled electromechanical system to produce smells from bottles mounted onto rotating disk [9]. People enjoyed multimodal movies with breezes and smells as well as through pictures and sounds, although not interactive. Entertainment attractions have also used scent; for example, Matsukura *et al*. [5] developed a scent-emitting system called "Smellitzer" that emits a selected scent to produce a sequence of smells.

Washburn [11] developed odor sensors and a blending system called "odor recorder". This research mainly focuses on how to sense, code and reproduce scent, very challenging projects that need continuous development. As mentioned above, these approaches are beyond the scope of our research.

Matsukura *et al*. [5] introduced an olfactory interface in a cylindrical immersive visual display. However, these works do not attempt spatio-temporal control in olfactory displays. One demerit of simple diffusers is the difficulty of dissipating a scent after it has been diffused in the air. This makes it difficult to switch or change the scent quickly in correspondence with the progress of a scenario or interactive application contexts.

Hirose *et al.* [3, 4] developed several head-mounted olfactory displays, including a scent generation and blending mechanism controlled by computer [3].

They recently developed a wearable olfactory display system [x10] that allows users to move freely. In these display systems, scented air was sent to the

nose through a tube. The visual display counterpart to such olfactory interfaces is, of course, HMD. McCarthy [7] developed an arm-worn olfactory display that focuses on the human habit of grasping a target object, bringing it up to the nose and sniffing it.

Recent attempts for implementation of olfactory display's was done by Matsukura *et al*. [5] that built an olfactory display capable of emitting scented materials through exploiting air collision and redirection capable of distrusting the scented material uniformly across the display's area and controlling the level of the air flow/direction using a computer software to control four fans mounted onto the corners of the display.

Another recent attempts was also introduced by Nakamoto and Hiramatsu [9] in their study, they developed an olfactory measurement system that uses pulse ejection. Unlike existing olfactory measurement techniques, their olfactory display employing pulse ejection measures olfaction by changing the ejection quantity to respond to various scent requirements.

Olfactory displays also been incorporated in health care applications to aid users to extensively sense the computer expressions, where in [2, 10] a novel multimodal interactive surgical simulator that incorporates haptic, olfactory, as well as traditional vision feedback. A scent diffuser was created and developed to interact with the simulation, in order to produce odors when errors took place in a simulated medical operation.

Several other olfactory displays are also introduced by Fukasawa *et al.* [1, 12] including a shoulder-mounted scent generator named scent collar, developed by the Institute for Creative Technologies (ICT). These olfactory displays realized interactive use of smell, but many were attached interfaces that required the users to attach a special device on the face, arm or other parts of the body.

Many people would probably reject the idea of wearing such equipment to incorporate an olfactory effect in existing systems, especially when primarily enjoying ordinary audio-visual contents.

Also, air cannons were introduced to launch scented air [5]. However, they simply filled the chamber of air cannon with scented air and thus they couldn't launch different smells within a short time.

Our system is a desktop peripheral that has scent-switching mechanism that diffuses scented oil/water mixture into a small cylinder with present air vacuum to force the molecules of scented material to mix with air and combining these results from several chambers and mixing the resulting into a main duct to be delivered to the user.

3. System Concept

The system as a number of operations that is performed from the movement of mouse till the generation of smell these operations are performed as quickly as possible to generated the corresponding smell before the user moves to the next object in the web page, it takes about 800ms to 2sec to produce the required smell by the system, the following is the system's three aspects.

3.1. Webpage Information Analysis

In this part the main focus is on how the web page is handled and the image is identified, recognized and required data are obtained.

- Website Image Extraction: The system core program checks periodically for the existence of a running instance of microsoft IE if it does not exists it will remain idle and minimized as an icon into the taskbar along with the clock and other programs, if it detects an instance of IE then it hooks to it and opens a virtual IE document inside the system capturing all events, data and code contained into the running IE, at the same time it connects to the IE cache storage in the operating system this is done because it is much faster to load the image to the system from the local storage instead of downloading it directly from the internet since its already on the system storage due to IE displaying that page, so the mouse move only gets a handle (web file name) to the picture under process, then the handle is processed to generate a file name corresponds to the actual file that resides into the storage.

IE uses the folder: "C:\Users\<username>\AppData\Local\Microsoft\Windows\TemporaryInternet Files\Content.IE5\" to retrieve the files of the web contents, noticing that this folder contains two files namely "desktop.ini", "index.dat" and "container.dat", the first contains the information about the layout of the folder itself and define it as special windows folder, while the other is the index of the internet cache, the third one contains table navigation information, in addition to at least one hidden folder with 8 alphanumeric random names (the number of folders increases with extensive usage of IE) as shown in Figure 1 which shows an example of the cache folder. Every time the IE wants to work with a file within it cache, it accesses "index.dat" and knows the where about of each file, to fetch that file from the corresponding folder.

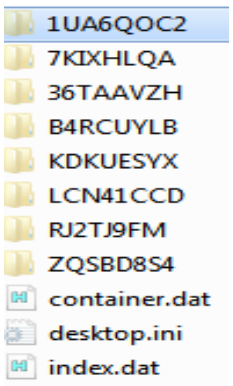

Figure 1. Example of internet cache folder.

The system acts the same as IE and performs file access in the same manner to fetch the file after conversion to a proper name such as adding "[seq.]" where seq. represents the sequence number of that file in case of duplication of file name due to the vast usage of internet and file accumulation into the cache with the same file names.

- Identification of Image Contents: After fetching the corresponding file, the Exchangeable Image File Format (EXIF) information is extracted such as file size and date and photographer along with capturing device name, these information called meta data and defined as "Metadata may be written into a digital photo file that will identify who owns it, copyright and contact information, what camera created the file, along with exposure information and descriptive information such as keywords about the photo, making the file searchable on the computer and/ or the Internet. Some metadata is written by the camera and some is input by the photographer and/ or software after downloading to a computer" [8] this data is processed to identify the nature of the picture into the file and to conclude meaningful information about the content, again files with enriched meta data is successfully identified, the first attempt the system will undertake is to identify the image from the file name this is the fact based on a statistics was made for each 100 image file the system captured about 77% of them are with meaningful file names, which used to identify the file directly the other 23% about 10% contains usable meta data, so, if identifying from its name fails it the system extracts the meta data and processes it, it this attempt is not successful it will neglect the file because it fails to identify it therefore no smell output will be generated.

The process of identification is quite simple and straight forward, the data collected from the file name or EXIF data is checked among a set of reserved words such as "lemon", coffee or soap, there are 60 word built in the system representing various aromatic object and the system accepts more from the user to store it with their corresponding hardware pulse representation. The matching process takes into accounts some identical word that matches directly to the reserved words and other that are "closely related" such as "lime" is mapped to "lemon" and "Nescafe", "java", "coffee" and "espresso" all mapped to "coffee" Algorithm 1 is a listing of the operation in pseudo code and Figure 2 is a flowchart showing the steps of the process.

Algorithm 1: Recognizing image content.

Step 1: *Fetch file name.*
Step 2: *If file name exists in reserved words then send to hardware.*
Else
If exact word dose not exists use likelihood of word then Send to hardware
Else
If no result of likelihood then
Load file and extract EXIF data
Compare extracted data to reserved words
If match exists then
Send to hardware
Else
Neglect file
End If
End If
End If
End If

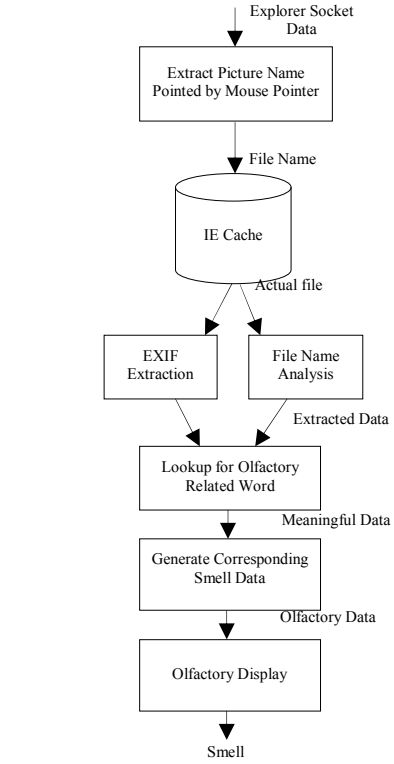

Figure 2. Flow chart of the identification process.

3.2. Communication Protocol

The communication protocol is based on USB communication link that has 64byte data transfer burst, the first byte is always zero, which is used for raw communication issues that not related to our olfactory display B_0, the second bytes indicates the speed of the main fan that delivers the scent to the user B_{fan}, the next pair of bytes is used as intensity level of how much scent will be delivered to the user each time that particular scent element is invoked or activated B_{int} and how much its specific fan will extrude of that scent material B_{ext}, so, the protocol basic capacity is denoted by the following formula:

$$Capacity = [64-(B_0+B_{fan})/(B_{int}+B_{ext})]^2 = ((64-2)/2)^2 = 961 \text{ possible combination of scent} \quad (1)$$

This is quite enough to be handled by our device, knowing that the data transfer rate will be equal each time the device is injected with data because the whole 64bytes are sent even if we were trying to activate one scent element, this is done to keep the device response time predictable instead of being changeable so, we

can deliver the scent in some sense on soft-real time [6].

3.3. Hardware Components

The hardware consists of a controller board to manage the voltage conversions and durations in addition to PC USB connectivity and an array of scent chambers filled with desirable scents, also, a duct system is needed to allow scent mixture if required. Also, the most important thing the open/close mechanism, all these entities will be illustrated next

- Controlling Board: Is a standard PC interaction board with a microcontroller PIC32MX534F064H that interprets signals from the computer system in other words getting the string values such as "lemon", "coffee" and "soap", etc., and converts it into a sufficient amount and duration of voltage pulses.

  The conversion process depends on a predefined table that each word correspond to a number of pulses with a specific duration for each one.

  The atomizers are devices that requires voltage levels higher than a PC can handle, the atomizers used has a voltage rating of 24v-48v this is beyond the capability of the PC, the controlling board was build to amplify the signal from the microcontroller to 24v supplied to each atomizer using IRL3103PBF MOSFET which can handle the voltage and draws a insignificant amount of current from the micro controller, in addition it has a very high switching speed, the circuit is connected as shown in Figure 3.

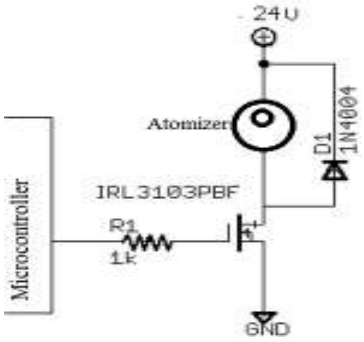

Figure 3. Typical scent element driving circuit.

- Scent Chambers: A set of small tubes used to hold the scent inside.
- Duct System: That is made of non smell absorbent material in shape of paths helps to mix the scents or redirect them or deliver it to the required cent terminal.
- The Open Close Mechanism: This is electrically controlled open/ close shutters and magnetic latches
- Purification Filter: It was noticeable that extreme and continuous usage of the system will render the room atmosphere saturated with different kind of aroma's sometimes results in fowl smells and odors, the purification system will neutralize these smells by running the air through an active carbon and silica gel filter that's capable of absorbing odors, in addition it can be used as a regular filter to purify the room's atmosphere, it consists of a PVC tube with two filters one is pleated filter to remove dust and other fabrics in the air the other is the active carbon with silica gel in addition to a fan to create the air flow through the filters, as shown in Figure 4.

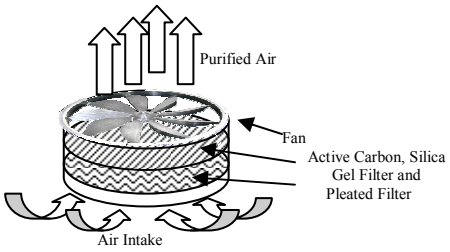

Figure 4. Purification and odor neutralizing filter.

4. Components Integration

These equipment are assemble together to form out olfactory display system and arranged as shown in Figure 5.

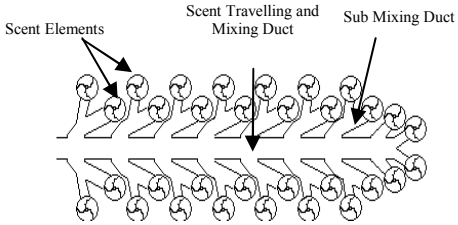

Figure 5. Arrangement of the scent element and duct pathway.

Each scent uses an atomizer Figure 6, element contains the scent material should also equipped with an open close mechanism that enables it to blow out the desired scent as shown in Figure 7. Notice that, the atomizer unit is used to turn the physical state of the liquid scent into a vapor that can be carried out with air to be blown out by the main fan of the olfactory display.

Figure 6. The atomizer.

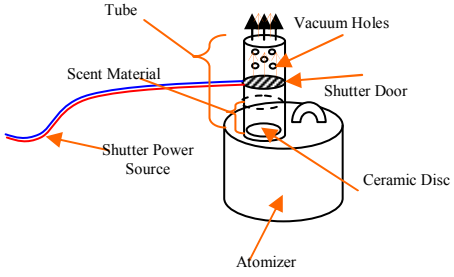

Figure 7. The atomizer with scent material and tube.

The atomizer that is used for mist generation reasons which we can used it as a scent element in the system, it function is quite simple yet very efficient. When the current passes through a magnet inside the atomizer's body its make the ceramic plate vibrate in ultrasonic speed which intern will scatter the molecules of the scent material, in result of this mechanical movement the scent material will instantly turn into vapour and emerge as smoke rising from the atomizer.

Using this atomizer in this system will increase the concentration of aromatic mist into air thus it can be used to directly vaporizing the oil based scent material into it mist instantly (0.1ml/second) using the ultrasonic technology to change the physical state of the scent material.

Actually there are several benefits for the usage of such technology its more to medical and health care to entertainment these benefits are shown below:

- Freshens the air.
- Aroma therapy.
- Alleviates allergies and asthma.
- Removes dust and pollen.
- No heat, chemicals or dry ice.
- Emits negative ions that help increase the humidity in a room, when using pure water.
- Also just running the main fan at full power we can simulate the effect of wind blowing into the users face.

Also, the control of such elements is closer to digitization of the output of the system, rather than using a fan yet it is smaller in size and easy to incorporate into the olfactory display.

Combining the atomizer with other elements to construct the scent element as shown in Figure 8, the figure shows how the effect of the main fan that reduces the air pressure inside the system which forces the air to pass through the small holes driving the particles of the scent material to the sub duct that's mixing with other scented material if it consisted of more than one ingredient, then passed through the main duct to be delivered directly to the user, the main duct is big enough to provide good air/ scent mixture to reduce the concentration of the scented material in order to be recognized by the user successfully due to high concentration of the material inside the scent element.

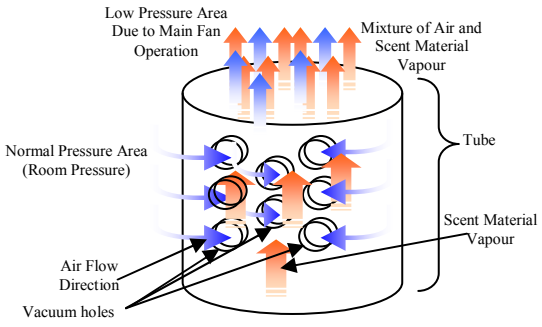

Figure 8. Atomizer vacuum tube.

5. Sent Generation and Detection

As the user moves the mouse over a desired image into a web site, the system captures the object of interest and checks whether user wishes to activate the smell generation with a enabling checkbox in the software interface, the analysis process begins to identify the image contents which will take 170ms in the best case scenario (the image name has meaningful information) this means the identification process resulted with a hit, on the other hand if the file name has no meaning or no hit found, the system tries to extract the EXIF tag from the image which will take $C+T_L$, where C in constant that needed to load the EXIF extraction component and equals to 796 ms for the first time only, and T_L is dependent on the size of the image file, the value of T_L is described in Figure 9.

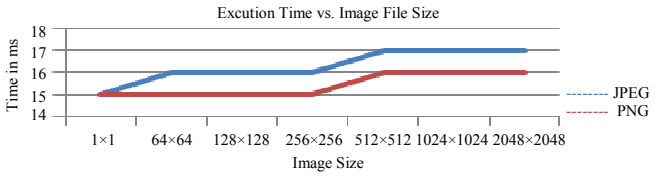

Figure 9. Execution time vs. image files size (T_L).

The next step is to make the matching with the extracted data which it takes about 900ms to finish populating arrays with data, comparing elements and finalizing the data array that forms the communication protocol, noticing for all use cases this 900ms time is constant, sending the data to the USB device takes around 1ms using 20MHz crystal in USB 2.0 mode, further more the microcontroller start energizing the atomizer instantaneously, the time that the atomizer starts to produce mist is measured using humidity sensor which responded in less than 100ms.

Most of the time is consumed by the fans that delivering the sent to the main duct system and the main fan that delivers the scent mixture to the user, it takes around 1 second to reach a user's nose sitting within one meter.

As a round up for all times it takes the system 2 seconds to successfully deliver the requested sent to the user (worst case scenario and 900ms-1.2sec in the best case scenario) plus time takes the scent to travel to the user's nose.

6. Noise Measurement

The noise measurement of the system is done using noise measurement software installed on android mobile phone OS called "Decibel-O-Meter" to find the noise level of our olfactory display to the user environment, we have a main fan that measures 50dB of noise and each scent element fan measures about 30 dB along with each atomizer which measures 45dB (with scent material eruption noise), of course the user might activate 1 to n number of scent elements so the total value of noise is measured according to:

$$Total\ noise = noise_{mf} + n\ (noise_{scent\ element}) \quad (2)$$

Where $noise_{mf}$ is the main fan noise, N is the number of scent elements and $noise_{scent\ element}$ is the total noise of each scent element since each scent element composed of fan and atomizer then:

$$\begin{aligned} &= noise_{mf} + n\ (fan_{sent\ element} + atomizer_{scent\ element}) \\ &= 50dB + n\ (30dB + 45dB) \\ &= (50 + n(75))\ /1dB\ (reference\ sound) \end{aligned} \quad (3)$$

For logarithmic measure of sound levels:

$$log_2(\ (50dB + n(75dB)/1dB(references\ sound)) \quad (4)$$

Figure 10 shows the relationship between number of scent elements and noise produced by our olfactory display.

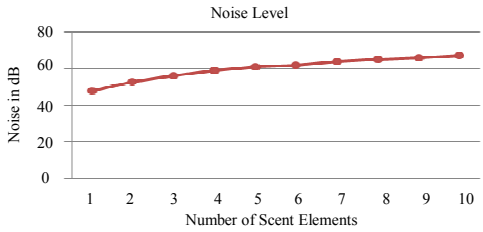

Figure 10. Noise generated from olfactory display.

7. Conclusions and Future Works

It is important to urge web site designers to use descriptive file names when using images inside the website, especially if the images are well enriched with meta data this is useful not just in the proposed olfactory system but to the system to avoid complex and time consuming operations to recognize the content of the image object.

It is better to use files that are already downloaded into the cache of the browser to extract the desired identification data rather than downloading it from the internet whenever the user moves to another image to reduce delay time so that, the olfactory display can react fast enough to produce the desired corresponding smell, knowing that there must be a way to inhibit this operation using the deactivate check box if the user wants to browse the internet without activation the smell generation system

Sometimes the user wants to use the system into a aroma therapy mode it can deliver smells on demand using a list of the desired smells with their time and duration of activation when the computer is on standby mode or the user just wants to freshens the air.

Adding air purification subsystem to continuously recycle rooms air through a carbon active filter to absorb the smells accumulated from several projections and to purify the atmosphere of the room. Since, the system uses atomizers one of the container contains pure water that can be stimulated repeatedly to humidify the air and add some moister to the room's atmosphere instead of purchasing a humidifier, air freshener and a purifier the system provide a wide range of services to the user with desired amount and time of delivery according to user's preference in addition to its original operation as a smell generator for internet browsing and e-marketing.

We recommend improvement of the system using bluetooth connectivity instead of USB wire connection so the user can locate the system where ever he desires, also implementing a panel interface for the device to enable the user to set/ activate the system to operate without the need of the computer to freshens the air and purify or humidify accordingly to user's preference.

Aggregate its usage not to be limited to websites but also for virtual reality and gaming in addition to video and movies, adding some features such as E-mail alert or download complete or any other operating system or application program generated alerts.

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