When Technologies manipulate our emotions – Smell Detection in Smart Devices

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Abstract— Smart devices have greatly transformed our lives; smart devices have affected the way we think, interact, and process information. As technology continues to grow, we expect more transformation caused by improved technologies. Videos, Images, sounds etc. are exchanged easily from one end of a smart device to a receiving end. However, the transfer of smell (Odour components) is still a major challenge in making devices “really smart”. This research seeks to lay a framework for the identification of odour component and the transfer of odour formulas among smart devices. The research proves that, with an assumption that if odour formulas can be transferred, the corresponding odour can be recreated on destination device using these formulas.

Index Terms— Smart devices, VOC, Piezoelectric material, E – Nose, Smell, Odour, Gas.

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1 INTRODUCTION

ODOUR comprise of volatile organic compounds usually emitted at varying low temperatures. The combination of one or more volatilized chemical compound produces corresponding odour component. The varying structures odour compounds take up make it difficult to be determined by a reaction of odour component with a specific chemical. Gas Industries have created odour detection channels, designed to detect specific gases. Taking advantage of the known reaction specific gases have with each other, the presence of such gases is detected when expected reactions occur.

For example, limewater can be used to detect the presence of carbon dioxide, Nitric acid reacts with sodium carbonate to form sodium nitrate, carbon dioxide, and water: $Na2CO3(aq) + 2HNO3(aq) \rightarrow 2NaNO3(aq) + H2O(l) + CO2(g)$ [1]. Combination of different gases produce reactions that are known over the years to signal the presence of a particular or group of gases. This process of gas identification is ideal for environments needing only the identification of specific gases. There is however no known formula of gases that can actively react with all odour components in the atmosphere.

No matter how tasking or impossible the identification and transfer of odour may seem to researchers, such development in technology will go a long way in handling several issues ranging from social to security.

2 RELATED ARTICLES

D The next big step to a new overwhelming technology for smart phones are the introduction of sensors. The Electronic nose (E-nose) probably may have made a positive step in the realization of this mind-blowing technology. The defence Advanced Research Project Agency (DARPA) conducted a research on the development of a new E- nose system that can be embedded in smart devices like mobile phones. This framework was built using mass spectrometer with the ability to monitor all elements in sample of VOC, and then compare against a database with common substances. Although this framework is still under design, Honeywell's ACS Labs principal research scientist Wei Yang is of the opinion that mass spectrometer can be miniaturized to fit in a smartphone [2]. However, this framework is yet to be seen implemented on smart devices. Although this framework promises detection and classification of individual components of gases, questions arise on the reduction of mass spectrum to fit into mobiles.

Ghenadii Korotcenkov in his work “Materials for Piezoelectric-Based Gas Sensors” covered various sizes piezoelectric materials can take and still be used for gas sensing [3]. Reviewing his work, we discovered that piezoelectric bases sensors can be implemented into the existing E – nose framework to create a smaller and more efficient odour testing channel.

3 BASIC COMPONENTS OF ODOUR

Unlike colour, which have three fundamental components of Red, Green, and Blue (RGB), adjusting the intensity of these three monochromatic primary colour, any other colour can be produced; [4] odour components however do not have these common fundamental compositions. However, odour components can be broken down into individual composition elements if the molecular compound formula is known. This research identifies the elements in the periodic table as the basic components making up odour compounds. With appropriate mixtures of gaseous elements, odour components can be produced.

3.1 Volatile Organic Compounds (VOC)

There are hundreds of VOCs. These VOCs can have high intensity of smell or low intensity depending on their concentrations. In humans, hundreds of VOCs exist. The human olfactory system detects smell from the body with a sensitivity level as low as 1 ppm to sub ppb [5]. It is therefore important that the sensitivity of any effective odour detection device should go as low as that of the human olfactory. The Human Olfactory function with high sensitivity and specificity in detection of odour. Biological noses are able to distinguish individual components of VOCs thereby easily creating reference to differences in VOCs. This level of sensitivity and specificity is required for VOC detection in smart objects.

3.2 VOC Identification by chemical characteristics

Odour molecules are detected based on their reaction with target sensing materials. Elements making up VOCs react when exposed to certain sensing materials. Properties like volume, mass, electric charge generation, molecular weights etc. can be used to identify wide range of elements. The corresponding change is then converted to an electronic signal by a transducer. Different types of transducers exist for chemical sensors. These transducers include electrochemical, heat-sensitive, optical and mass sensitive. Our framework utilizes a combination of different sensory array, based on the operation of the E Nose to achieve transfer of VOCs over smart devices. Among the different characteristics of elements, we are more interested in the molecular weight of compounds. The molecular weight of compounds remains a unique attribute in identifying compounds. If composite elements in ambient air can be identified by molecular weights, their corresponding formula can be fetched from a database of known molecular formula and weights.

Of certain, VOCs do not come pure in real life scenarios, the complex mixture of VOCs make it difficult to identify individual weights or masses of composite elements. Using the combined functionality of the E nose with a preprogramed piezoelectric computerized circuit, we hope to retrieve clue to individual properties of composite gases in a VOC.

3.3 Electronic Nose

Full-length Electronic nose (E-nose) was first developed in the 1980s; it was designed as a smart instrument for detecting and distinguishing complex odour[6]. With the knowledge of the human olfactory, the E nose system was built. The typical E-nose devices includes a sampling system, an array of chemical gas sensors, an analogue to digital converter (ADC) and a computer microprocessor with sample classification methods (Pattern-classification algorithm).

Fig.1 shows the detection process of electronic nose in reference to the biological nose [6].

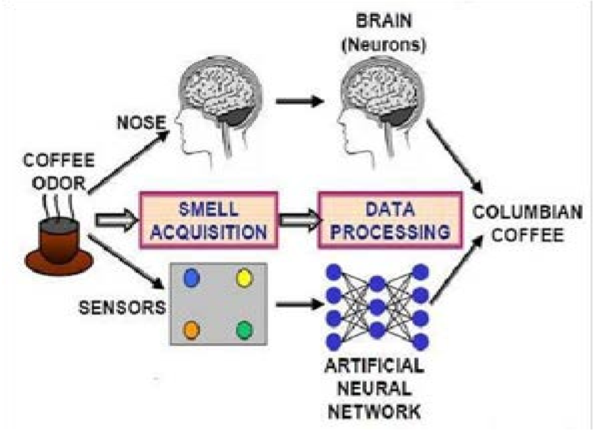


Fig.1 Relationship between the E-nose and the biological nose

The E nose mimics how the biological nose function. Using wide array of sensors, the E nose is able to detect complex VOCs. Particular odorants are detected based on the unique respond pattern from all sensors. This ability of the E nose makes it sensitive to wide range of VOC if programed. With its neural network, the E-nose is able to pick out particular odour components. Improving the function of the E-nose simply entails increasing its knowledge base of known odorants. This is possible through training the E-nose in an ideal environment.

3.4 Quart Crystal Microbalance (QCM) Sensors

The quartz has the ability to convert pressure into electrical pulses. Quartz crystal microbalance is a type of microbalance mass sensor. The QCM consists of a transducer, which is mass sensitive. Using a bulk acoustic wave sensor, the QCM is able to identify gases by mass. Sensors are coated with PVC blended lipids and molecular imprinted polymers thereby increasing the sensitivity and specificity of the QCM. Widening the range of specific Identification of gases (gaseous elements) in the QCM will involve training and recording changes observed when specific gas elements are introduced into the QCM system in an ideal environment [7 -8].

Combining the functionalities of the E nose with the mass identification property of the Quartz Crystal Microbalance (QCM) sensor using piezoelectric material, we develop a framework that will identify individual components of a VOC by molecular mass, retrieve chemical formula of Gases and transfer chemical formula of identified VOC to another smart device for replication.

4 METHODS

This research paper expanded on the E-nose using piezoelectric devices to pick up molecular weights of gases. The sensors in E nose are designed to react with gases. The piezoelectric device pickup these gases as they pass through different sensors, the weights of the gases are then compared with existing molecular weights of gases on the periodic table. The weight of the gases are also compared with the charges they create, mapping the charges and weight with corresponding values of known gases in the periodic table, the molecular formulas of the unknown gas can be determined. The Fig.2 illustrates the cor

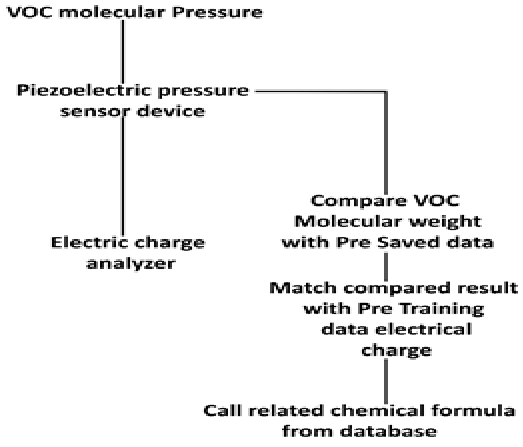


Fig.2 A flowchart of the process after collecting gas samples from the E-nose

VOCs molecular pressure is retrieved via a thin pipe, the piezoelectric pressure sensors picks up the molecular weight and charge produced by the gases. The molecular weight and the electrical charge created are processed independently and compared with existing records of gases. If records match known gases in the database, the formulas of the gases are retrieved and can be transferred to another device and reproduced. The Fig.3 indicates the flowchart representation of this project framework.

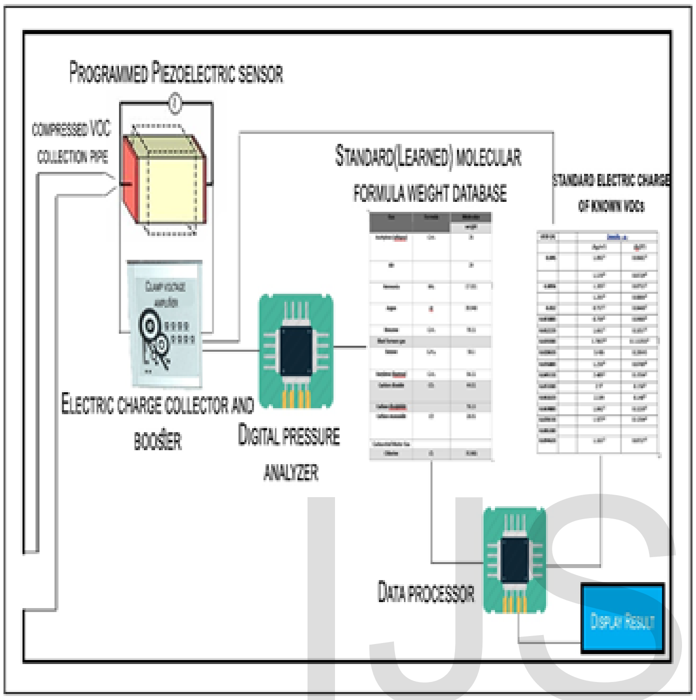


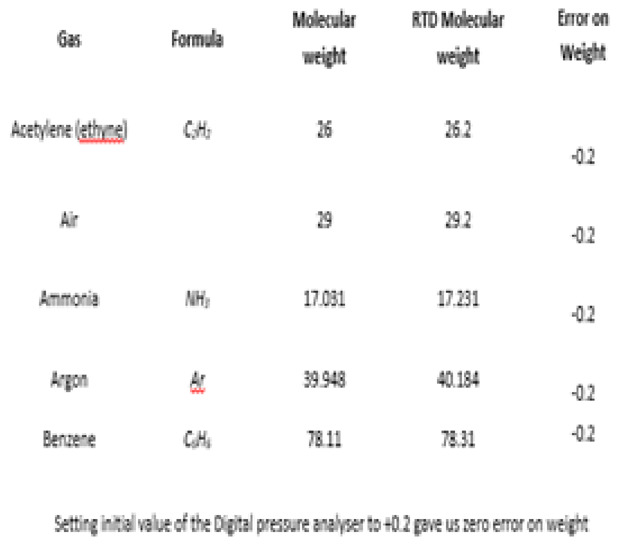
Fig.3 Representation of the Project Framework

4.1 Experiments

In this research paper, researchers simulated based on two different environments as; Ideal environment (Pure VOC without impurities) and Real environment (VOC mixed with impurities).

a) The Ideal Environment

In the ideal environment, we ensured an impurity free process. We conducted tests introducing concentrated Acetylene (C2H2) into the channel. Although detection period was slow, the molecular weight of Acetylene was returned with and error of 0.2 g/mol. We continued with the experiment by introducing other gases into the channel. The Fig.4 below shows the results gotten from other gases.



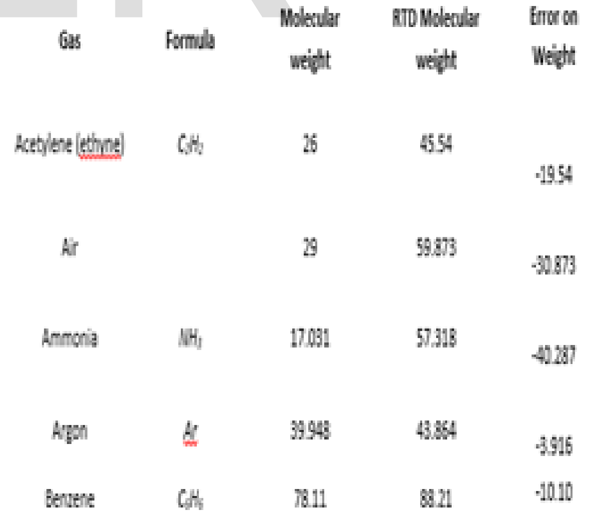
Gas	Formula	Molecular weight	RTD Molecular weight	Error on Weight
Acetylene (ethyne)	C_2H_2	26	26.2	-0.2
Air		29	29.2	-0.2
Ammonia	NH_3	17.031	17.231	-0.2
Argon	Ar	39.948	40.184	-0.2
Benzene	C_6H_6	78.11	78.31	-0.2

Setting initial value of the Digital pressure analyser to +0.2 gave us zero error on weight

Fig.5 tests result for gases (Ideal Environment)

b) The Real Environment

In the real environment, we allowed impurities in the channel by introducing dust particles and carbon compounds. Introducing Acetylene (C2H2) into the channel produced a way different result from that done in the Ideal environment. We continued experiment introducing other gases into the channel. The Fig.6 below shows the results gotten from other gases.



Gas	Formula	Molecular weight	RTD Molecular weight	Error on Weight
Acetylene (ethyne)	C_2H_2	26	45.54	-19.54
Air		29	59.873	-30.873
Ammonia	NH_3	17.031	57.318	-40.287
Argon	Ar	39.948	43.864	-3.916
Benzene	C_6H_6	78.11	88.21	-10.10

Fig.6 tests result for gases (Real Environment with dust particles and carbon compounds as impurities)

4.2 Discussion of Experiment Results

The experiments carried out in different environment with same gases as sample produced different results. The results gotten from an ideal environment returned a steady addition of 0.2 g/mol on the original molecular weight of gases introduced. The results gotten from the real environment however where not consistent. According to our experiment, it is clear that this framework cannot work in real environments with unknown impurities. However, adjusting the piezoelectric processor in the ideal environment solved the problem of the 0.2g/mol error thereby making it possible for the system to fetch corresponding gas formulas.

4 CONCLUSION

It is interesting how smart devices have developed over the years, despite tremendous milestones already accomplished by smart devices, efforts are still being made to make smart devices smarter. Embedding smell detection and transfer on smart devices will not only make smart devices more attractive it will affect largely how we relate emotionally with these devices. In the cause of this research, we discovered the complications facing researchers in coming up with a perfectly sized odour detection and transfer framework that can be embedded into smart phones. Tentacles have spread into Nano sized piezoelectric materials in searching for sensing objects of small sizes that can serve as odour testing devices and still allow for integration into small devices. The small size of nanomaterials provides the possibility of miniaturization and integration of large number of devices [9]. With the use of miniaturized piezoelectric materials, large odour detection architectures can be incorporated into the design of smart devices.

Using miniaturized piezoelectric materials to detect odour, we discovered odour components are made up of volatile gases, which have unique molecular weights. Each element possess unique attribute that we can use to detect their presence in a mixture. Our channel was developed on the already existing framework of the e nose. We introduce a computerised piezoelectric material that retrieves gas components by analysing their masses and electric charge generated. The mass and charge retrieved are then mapped over a database of known molecular mass and charge. If a successful mapping is created, the molecular formula of the corresponding VOC in the channel is retrieved. This molecular formula now acts as the basic components for the recreation of the VOC (similar to the generation of thousands of different colours from the basic RGB primary colour).

Our experiments proved that VOC detection and transmission via molecular formulas is possible for smart devices using this model, however we faced some challenges when large quantity of impurities where introduced into the channel containing our test VOCs, our framework however, has not included a solution for this problem.

For further studies, we hope to implement in this model a mechanism able to filter large impurities from real VOCs thereby making our solution more efficient in real life scenarios.

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