Advances in Intelligent Systems and Computing 794

Tareq Z. Ahram · Christianne Falcão
Editors

Advances in Usability, User Experience and Assistive Technology

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Tareq Z. Ahram · Christianne Falcão
Editors

Advances in Usability, User Experience and Assistive Technology

Proceedings of the AHFE 2018 International Conferences on Usability & User Experience and Human Factors and Assistive Technology, Held on July 21–25, 2018, in Loews Sapphire Falls Resort at Universal Studios, Orlando, Florida, USA

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Editors
Tareq Z. Ahram
University of Central Florida
Orlando, FL, USA

Christianne Falcão
Catholic University of Pernambuco
Boa Viagem, Pernambuco, Brazil

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Advances in Human Factors and Ergonomics 2018

AHFE 2018 Series Editors

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9th International Conference on Applied Human Factors and Ergonomics and the Affiliated Conferences

Proceedings of the AHFE 2018 International Conference on Usability & User Experience and Human Factors and Assistive Technology, Held on July 21–25, 2018, in Loews Sapphire Falls Resort at Universal Studios, Orlando, Florida, USA

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Preface

Successful interaction with products, tools, and technologies depends on usable designs and accommodating the needs of potential users without requiring costly training. In this context, this book is concerned with emerging ergonomics in design concepts, theories, and applications of human factors' knowledge focusing on the discovery, design, and understanding of human interaction and usability issues with products and systems for their improvement.

The Human Factors and Assistive Technology promotes the exchange of ideas and techniques which enable humans to communicate and interact with each other in almost every aspect. The new relationship between humans and technology added convenience for many, and for those with impairments, modern-day technology has transformed their daily living into a journey toward capability instead of disability. Assistive technology assessment focuses on the examination of problems in designing and providing assistive devices and services to individuals with disabilities or impairment, to assist mobility, communication, positioning, environmental control, and daily living. The conference addresses a wide spectrum of theoretical and practical topics related to assistive technologies. It provides an excellent forum for combining real experience and academic research, while examining how we can adapt to machinery and increase the technology acceptance, effectiveness, and efficiency. The conference aims at investigating how psychological factors can affect the efficiency and acceptability of assistive technology.

This book will be of special value to a large variety of professionals, researchers, and students in the broad field of human modeling and performance, who are interested in feedback of devices' interfaces (visual and haptic), user-centered design, and design for special populations, particularly the elderly. We hope this book is informative, but even more that it is thought-provoking. We hope it inspires, leading the reader to contemplate other questions, applications, and

potential solutions in creating good designs for all. The book is organized into nine sections that focus on the following subject matters:

Section 1: UX Evaluation and Design Thinking
Section 2: Human Machine Interfaces
Section 3: Usability Evaluation and User-Centered Design
Section 4: Virtual Reality and Interaction Design
Section 5: User Experience in Healthcare and Learning
Section 6: User Experience and Visualization in Automotive Industry
Section 7: Eye Tracking and Visualization
Section 8: Assistive Technology and Design Solutions
Section 9: Assistive Design Solutions and Prosthetic Environments

This book will be of special value to a large variety of professionals, researchers, and students in the broad field of human–computer interaction, usability engineering, and user experience research, who are interested in feedback of devices' interfaces (visual and haptic), user-centered design, and design for special populations, particularly the elderly.

Each section contains research papers that have been reviewed by members of the International Editorial Board. Our sincere thanks and appreciation to the board members as listed below:

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We hope this book is informative, but even more thought provoking to inspire the reader to contemplate other questions, applications, and potential solutions in creating good designs for all.

July 2018

Tareq Z. Ahram
Christianne Soares Falcão

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Digitalize Limits for Increased Capability: Technology to Overcome Human Mechanisms

Mila Stepanovic(✉) and Venere Ferraro

Department of Design at Politecnico di Milano, Milano, Italy
mila.stepanovic@mail.polimi.it

Abstract. Senses help us go through everyday life. Thanks to our natural senses we can orientate in the space, recognize danger or pleasurable experience. In this text we will treat problematics of loss or damage of the Sense of Smell (Olfactory System) and investigate how does this event change everyday life and perception of the world around us. The objective of this text is to show importance of empathy related to the complexity of the pathology and the importance of the design for Assistive Technological (AT) devices; in this particular case, investigate possibilities of technological devices in improving quality of life by increasing one's capabilities related to Human Mechanisms, where we refer to smell experience. In regard, we will describe the Case Study based on workers' perception of the risk in Coating Plants, that largely rely on their sense of smell, which as a consequence impacts their health condition.

Keywords: Human capabilities · Olfactory system · Assistive technology
Olfactory loss · Perception · Occupational disease · Prevention

1 Introduction

Since antique Greece, philosophers as Plato and Aristotle discussed about the phenomena of senses and sensation, and its importance in knowing the world and ourselves. Plato claimed that the consciousness stands exactly for *the sense* [1]. He considered that the truth is related to what is perceived [1]. On contrary, Aristotle believed that the smell is a secondary sense for humans because it will never be as accurate as animals' one [2].

It is important to emphasize the fact that the Sensory perception is a biological phenomena [3]. All forms of the life have sensory perception [3, 4]. Plants are sensing the Sun; animals are capable of sensing danger, pray or partner for coupling; even single-celled amoeboid is capable of sensing [3, 4]. Also humans use their senses to focus on outside world, orient in the space and communicate with each other and environment; but the difference comparing to animals is that humans have the capability of experiencing on higher cognitive level [3–5]. It is thanks to our senses that we have a perception of ourselves, of "being in the world" [4].

If senses are so important for humans, what happens when one or more senses are loss or damaged? - Certainly this event changes our everyday life, the way in which we are interacting with each other, with objects and environment [6].

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Technological evolution helped development of devices that are able to replace some human mechanisms or organs, and assist in completing activities. For instance, some fields of design and technology application are focusing on individuals with specific problem or impairment. Thus, we can consider that technology has a potential to be a digital extension of human natural capabilities or mechanisms [7, 8].

Assistive Technology (AT) aims at improving users with impairment but also support the life and daily interaction of individuals. There are different types of Assistive technology (AT) and mode of uses. From automatic digital to analog, from commercial to personal, from replacing the body part to technological wearable device ecc.

In this text we will investigate problematics that occur when the sense of smell is lost or damaged, its causes, and finally propose a technology as a solution for improving the life of individuals with olfaction impairment.

This research will be supported with the Case Study that is referring to the workers in Coating Plants, which after long exposure to polluted air have reduced sensitivity to odors and as a consequence also the low perception of the risk.

2 Sense of Smell

In all moments of our lives we are perceiving different kinds of smell. Sense of smell is considered to be a secondary sense compared to audition and vision [9]. Still it is the very important factor in experiencing the world and people around us. We are realizing ourselves trough our smell but also we are relating to others by smell; like smell of our mother, people that we frequent regularly [10].

Animals are using olfactory system not for abstract experiences but for survival, reproduction, and discovering sources of nutrition [3]. Differently, humans are living experiences trough their senses, evoking memories and emotions [4, 5].

We perceive odors principally as pleasant and unpleasant [4, 5]. Human sense of smell can indicate whether there is a danger in the environment and generally the quality of the things that we consuming or being in contact with. Even tough our ability to sense is very important it is not always reliable, and not only, it is certainly less developed than animals' one. This means that even healthy olfaction system is not able of detecting all odors and certainly not all with a same intensity.

Sense of smell is in a tight relation with a sense of taste. Eating information is geathered also from sense of smell (olfaction receptors) and this is contributing the eating experience by emphasizing the taste of food [4]. This means that there is more possibility that if we do not like the smell of something, we also won't like the taste of it [4, 5].

In the following text we will observe all these biological and cultural facts of odors and human sense of smell, but also pathologies and possible difficulties that occur due loss of capability of sensing.

2.1 Importance of the Sense of Smell: Individual and Cultural Factors

Human are capable of recognizing over thousand different odors; but we can also loose completely the sense of smell [5]. The main role of our senses is to unconscious

monitor what is around us; senses help us to focus our attention on specific thing and describe feelings and space [4, 5]. Each thing that is sensed is translated in perception - perception is the image or experience of what is sensed.

Our nose is able of recognizing both near, direct odors (e.g. spoiled food) as those sparse in the air (e.g. smoke, pollution) [4]. This function of our nose is enabling the olfactory epithelium with receptors that is detecting molecules and register scents [4].

It is considered that the odor perception - the experience and memory evoked trough sense of smell - is not as accurate as auditory, visual or tactile input [4].

Scholars are arguing about if there is a Mental Imaging for the sense of smell [11]. Mental imaging is creation of mental representations that are strongly based on imager's will [12]. Some researchers are claiming that there is odor imaging while some others retain that it is not possible to generate odorlike mental images, or that this sort of imagination is rather poor [11, 12]. Beside imaging as a mediator in recognizing odors, it is also difficult to find a correct linguistic designation for describing odors [10]. It might be that these two phenomena, of odor imaging and linguistic characterization of odors, are related [6]. The emotional vividness may be exchanged with the imaging [4]; there so, it is believed that lack of semantic information it is very difficult to classify precisely odors. Odor imaging would be a semantic mediator that help in recognizing quality of what we are smelling, or provide higher accuracy of human sensing [12]. Anyway, encoding smells in our memory is not only possible but normal, we are all encoding different smells within possibilities of our nose and sensitivity [13]. Sensory perception is a strongly subjective experience of individuals [4, 5]. Fortunately the most of us are able of recognizing odors and use the sense of smell in efficaciously [10]. Odors that we meet more frequently during the life are also more easily recognizable (i.e. fragrances based on lemon or roses); on contrary, too frequent experiencing of same odor, or exposure to it, may also decrease sensitivity of nasal epithelium [5]. The fact that there is a memory and experience related to sense of smell is confirming that there is a relation between sensory system, lifestyle and environment [3–5]. Human sensory system is detecting the quality of environment and the individual is adopting to it [3].

Some levels of pollution, fire or spoiled food a healthy olfaction system is recognizing, actually these are the most important functions of our olfaction system [13]. Human brain has a role of interpreter of what is sensed [4, 9]. Perception about something is created in our brain and it is an active process depended on a lot of factors, both biological and cultural [3, 4, 9].

The quality of life certainly change in anosmic patients (patients with damaged olfactory system) comparing to normosmic (normal functioning olfaction system) [13]. Especially segments of life related to food and social relations are showed to be poorer in anosmic patients [13]. Other very important segments of life influenced negatively by olfaction impairment are safety, eating and personal hygiene [13].

Inhalation as a process of breathing was very important for Christian and Jewish tradition and religion [14]. The Bible is describing The Creation of Man with a scene in which the God breaths the soul into Adam (Gen. 1:7). Whereas in the Old testament fragrances were related to dark realm of sexuality [9].

In Jewish tradition the smell is strongly related to the Sabbath, where this sacred day was different from other weekdays with introduction of fragrant herbs [14].

In the Jewish tradition was also believed that the smell is bringing the seal of Lord, or as later was taught, the nose is a seal of God set on our faces [9].

Historically, people became more interested in smell of themselves and their clothes from the end of eighteenth and beginning of nineteenth century [15]. This due the reduced economical and social differences and the first commercialization of soaps, deodorants and generally products for hygiene [15]. This was the historical period in which we started the war against smells; not only with personal hygiene but also with smell of environment. Smell of our habitat changed as cause of pollution and due usage of fragrances to reduce bad odors.

Related to historical evolution of smell it is evident that the smell had its social, significant and semiotic function and that these were changing in time [15]. Like from more basic musk odors to elaborated floral fragrances for personal use ecc [15].

This phenomena is related also with a fact of how close we are to the nature today. Scholars are claiming that now a days we have less developed sensitivity to odors that our ancestors because we are distant from nature [15].

Problems in perceiving smell can occur in few ways: when there are few odors in the same environment and they are getting neutralized, when there is some physical problem or ill-ness that damaged Olfaction system or when we are exposed to certain odors for a long period so it cannot be perceived anymore or not with the same intensity as before. But beside physiological characteristics and diseases that cause damage of olfaction system, smelling as a human cognitive action is almost distinct in developed societies. We are not capable of bringing accurate conclusions about the quality of what we are smelling, as it was once where the perception about odor was strongly focused on survival, reproduction, orientation and in general nature and its characteristics.

2.2 Causes of Loss or Damage of Sense of Smell (Olfactory Disorders)

Olfaction disorder is quite common as pathology, while its consequences are significantly less known [13]. Loss or damage of sense of taste and smell is not considered for disability. Sensory impairments are related to following: deafness and hearing impairment, blindness and visual impairment and deafblindness.

Even if the sense of smell is not playing that important role in medical sense, it is very important for experiencing the world. The system that is enabling smell sense is called Olfaction System. For functioning of Olfac-tion System it is very important the role of the brain (neurons). The role of brain is to interpret smells – create perception [4, 5].

The Olfaction system is divided in two parts: Central and Peripheral. The receptors in the nose and olfaction nerve are considered as Peripheral part, the part that is receiving and sending information to the brain. The Central part is the Olfaction Bulb where is the brain part associated with memory and feelings [4]. Olfactory performance is determined by interactions occurring in peripheral part (early processing) and central part (higher order processing) [16]. There are different etiologies for olfactory dysfunction that can be caused by damaging one of two extremities of information processing (peripheral or central), or it can be caused by some other pathology (physical or cognitive). Typical diseases that are causing olfaction dysfunction are sinonasal disease, upper respiratory tract infections, exposure to hazards, neurodegenerative diseases but also it can be a result of congenital nature [16]. These are very direct causes of

olfaction damaging, but there are also some other diseases that may lead to loss of sense of smell, as Alzheimer and Parkinson, especially in elderly population.

What was of particularly interest in this research is olfactory loss due long exposure to hazards. Exposures to pollution and hazards is very common way that brings to olfactory damage. During a long exposures to particular odor human develops habit to it. Developed habit is reducing a sensitivity to specific odor and perception about the risk (hazard substances present in the air) decreases as a consequence. Being less aware of pollution is certainly increasing the possibility of higher exposure and there so more severe disease progress may occur.

What we propose in this research is that when there is a limit of human natural senses there is a necessity to introduce technology able of replacing or increasing human capability, and for introduction of technological solution it is necessary to observe pathology and causes. Value of Technology implementation is in providing the objective data instead of human sensing that is based on subjective experience.

3 General Observation of Assistive Technology (AT) and Its Potential

Assistive Technology (AT) is defined as any technology, or technological device, service or equipment, commercial or not, able to assist the user with some sort of disability (physical or cognitive) by maintaining, increasing or replacing damaged human function or mechanism [7, 17, 18]. Basically the role of Assistive Technology is to make actions easier or possible to do [13].

Assistive Technologies certainly had its growth with a technological and economical development that brought to changes in assessment and costs, giving a possibility to everyone being a part of it [19, 20]. Particularly development of microelectronics contributed in creating new devices of small size with high performances but also reduction of costs of production and electronics [20]. In the past years we were witnesses of pervasive diffusion of technology and development of IoT (Internet of things). These events make believe that the technology may have advantage or utility for all kind of purposes, even if most of the time it is not like this. It is needed to create right condition for having effective results from technological products, as creating technologies that are used only when indeed it is needed and that can guarantee good quality products that correspond to technical standards and market, and user requirements [17]. Successful technological devices have to adopt to the capacities of the end users, his level of knowledge of informatics and physical and cognitive capabilities [17].

Beside technical and technological characteristics and innovation, very important factor for creating good Assistive Technological products is Design and Engineering as disciplines, with its processes and methods.

When designing assistive devices or applications it is important to take in consideration empathy toward pathology and human condition and engagement of the user in design process. Understanding if the level of innovation and generally application of technology is comprehensive, feasible and accurate is possible by introduction of prototypes and engagement of the user in design process.

Assistive Technologies have both social and individual importance. The formal factor is not less important than technical and functional one. Assistive Technology is not invisible, neither neutral [21]. It is the part of the user and often it is very visible and perceived by the users as stigma, there so it becomes a barrier between the user and environment and the main reason of abandonment [21]. Successful assistive device should fall in a background of daily life, not to give the impact.

Assistive Technologies even if dedicated to personal use often involve also the family of the user. In order to avoid collective frustration these devices have to be easy and comprehensive for use [14].

Beside home use Assistive Technologies can be part of the healthcare system or have a form of a service provided to the user [7]. These applications are often used for rehabilitation purposes [13, 17].

There are numerous digital assistive devices that support different needs. From those more common as hearing device to advanced body prosthesis. Other fields of application of Assistive Technologies are related to the vision, orthopedic and among all the mobility sector. Another field of interest is cognitive and motor disabilities, both in case of elderly (Alzheimer or Dementia) and congenial and pathological problematics, where the most common assistance is applied in sense of education, social participation and communication [14].

4 Case Study: Plurisensorial Device to Prevent Occupational Disease

In the previous text we investigated the field of Assistive Technologies and in particular sense of smell, characteristics of olfactory system and experience related to it. Observing the causes of loss of sense of smell we noticed that typical cases are related to long exposure to hazards which cause serial infections that may result as damaged olfactory system (1), often it happens as a process of ageing (2), as a result of other pathologies (3), and due injuries that damage peripheral or central part of olfactory system (4). Here we will focus on the risk of losing or damaging sense of smell as a cause of long exposure to hazard substances in specific working environment.

Our research was developed on findings evolved from the Transnational Research Project (SAFЄRA Joint Call 2014) called "POD-Plurisensorial Device to Prevent Occupational Disease" with a focus on specific environment and group of users - workers in Coating Plant. These workers are highly exposed to Volatile Organic Compounds (VOC) that are present in the environment. In Coating Plant environment is highly recommended wearing of Personal Protection in order to prevent numerous health problems that can occur after long time exposure. These pathologies are always related to respiratory tract, and occur initially in form of irritation, allergy, chronical bronchitis, asthma, chronic obstructive pulmonary disease (COPD) and in worst case lung cancer.

In the following text we will show the Case Study based on the context of Coating Plants, where is common decrease of sensitivity to smell as a cause of long exposure to hazards, which can lead to develop more severe diseases. We will suggest as a solution

to this problem an assistive device based on sensing technology and design process based on empathy and user engagement.

4.1 Problem Identifying: Empathy Phase

A report of the Scientific Committee on Occupational Exposure Limits (SCOEL) highlights that workrelated exposures are estimated to account for about 15% of all adult respiratory diseases. The last INAIL (Istituto Nazionale Assicurazione Infortuni sul Lavoro) report on occupational diseases showed that the working places with the highest percentage of respiratory diseases are agriculture, manufacturing and transportation sectors [22].

Our research started from these facts and went forward to observe workers and the environment in which they are working. Objective of the User Session was to understand why still today there are so many cases of occupational disease within this sector, despite provided protective equipment and general evolution in health prevention methods. In order to understand general problematics and characteristics of Coating Plants we proceeded with observation of workers during the working performance that was followed up with the interview formulated in the way to understand the perception of workers toward health, risk and prevention and on the other part understand their level of technological devices manipulation and comprehension.

Geathered results showed that generally risk and health perception of workers is on low level because it is not easily perceivable. Situations in which they are perceiving more exposure to risk are those in which there is a overspray. The visual perception is overwhelming the smell perception. Visible representation of paint is a sort of semantic information about the exposure risk to workers.

Even tough wearing of Personal Protective Equipment (PPE), is highly recommended within Coating Plants, workers are rather avoiding to wear it because they do not see the realistic utility of it.

Interesting fact that came out of our discussion with workers is that they were not perceiving the smell with the same intensity as us, that we were there for the first time. After a long time exposure they lost sensitivity on odors in Coating Plant. This condition is preventing them from responsible health behavior and increase possibility of developing respiratory diseases in future.

Here we found as a suitable solution application of technology with a purpose to inform and alert worker about environmental pollution, make more visible risks that they are exposed to.

4.2 Development of Device

Results from the Empathy phase brought us to the complex solution based on sensor technology. Here we will briefly describe the system and than we will focus on the main part of it which is the Electronic Nose Device able to detect Volatile Organic Compounds (VOC) and provide the real-time feedback to the user. Aim of this kind of system is to communicate the risk trough objective data to user and during the time change user's perception and raise consciousness about health risks.

The system that we will introduce is the Plurisensorial Device to prevent Occupational Disease which is an interactive and protective wearable system that consists of four parts: Protective Mask (1), Electronic Nose Device (2), Respiratory Chest Band (3), Mobile Application (4). All these parts of the system communicate one with another and provide a feedback trough the Mobile Application to the user, about the environment and personal vital parameters, in the linear comparable way so that the worker can have a complete image about how environment impacts his health compared to when the protective mask is worn and not. This sort of system is based on sensor technology and Bluetooth for information transfer.

The most important part of this system is Electronic Nose Device which is the "brain" of the system. Electronic Nose Device (Fig. 1) is developed as a support device for worker that offer real-time feedback about the air quality.

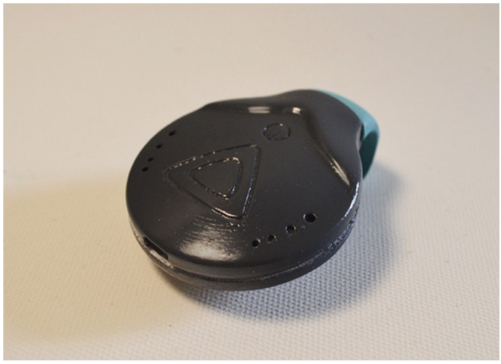

Fig. 1. Electronic Nose Device prototype

This device is a mediator to inform the user about the level of hazard substances in the air and remind him to put the protection. Device's sensor is calibrated to detect three levels of air quality: good (1), the air is getting polluted (2) and the high exposure to hazards (3). The device is giving visual and tactile feedback in form of colored LED and vibrations, set respect to three levels in the mood of three colors – green, yellow, red – and three vibration level – low, medium, high (Fig. 2). Vibrations of the device are designed to be continued in order to force the user to look at it, because the only way to stop vibration is to press a button on it.

Here we tried to activate other senses (vision, touch) because the sense of smell is not validating in accurate way the condition. As workers claimed, only when the risk is visible or the clothes that they are wearing is dirty of colors they remember that they are exposed to toxic substances. Giving a real - time visual feedback tries to operate on this level, emphasize the visual perception, while with vibration is activated the tactile one, and in this way provide the objective data related what is not perceivable with a nose.

Detecting the polluted air as a human physiological function is not enough developed to diverse all kind of hazards, and not all with a same accuracy. In the case of our workers this is even less valid because their developed habit to this kind of

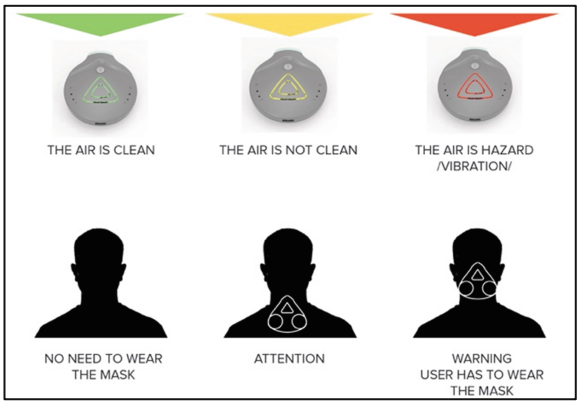

Fig. 2. Use cases Electronic Nose Device

odors, or as many of them have already irritated or damaged epithelium their sensitivity on odors is on very low level. Purpose of technology in this case is to arrive where human mechanisms are not able and prevent development of more sever diseases. Electronic Nose Device is a sort of assistance to our nose and perception.

5 General Discussion

In this text we wanted to show an alternative application of assistive technology and emphasize the problematics of loss or damage of sense of smell that is often taken for grant.

The sense of smell has certainly great impact on our lives and experiencing. Problematics of loss or damage of sense of smell are not related only on hedonistic characteristic of smell experience, but also to a numerous risks that one is exposed to when not being able to perceive odors as smoke, hazard substances, gas, spoiled food ecc. Not being able of perceiving polluted environment may lead to a continuous exposure and to development of various diseases or intoxication.

We showed in our Case Study the context in which workers often suffer a disease after long exposure to hazards because they smell perception is not accurate anymore.

For this particular case we developed Device able to detect Volatile Organic Compounds (VOC). Potential of this kind of device is in its flexibility and versatility - possibility of integration in different sectors. Value is in its capacity to go beyond human limits and give precise, objective data and provide immediate feedback. Having a possibility of real - time feedback is in reducing the time gap and provide continuous assistance.

There are many sectors in which this problematics is present and that it can be resolved by introducing sensor technology and devices designed to increase capabilities, that are strongly based on understanding the complexity of the pathology.

6 Conclusions

In this paper we interpolated principally two arguments: importance of the empathy toward pathology as in this particular case Olfactory Disorders (1), and design of Assistive Technologies (2).

We were interested in understanding the daily problematics of the people living with damage or loss of sense of smell, how they experience the world and potential risks that they are exposed to.

Our findings are that, even if it is taken for grant, sense of smell is very important human factor and that the damage of it may bring a numerous complications, from those related to pleasurable experiences as eating, interpersonal relations, habitat recognition; to those related to danger perceiving. With a loss of sense of smell all these characteristics and activities of our life deny.

Assistive Technology (AT) has a potential to become a protagonist from where human limits begin. Introduction of Assistive Technology in lives of people with reduced sensitivity or complete dysfunction to odors may effectively increase capabilities and independence. It could prevent from eating spoiled food, to recognizing fire smoke and different hazard situations.

When one of the senses are lost there is a necessity to emphasize function of other sense, as we saw from the example of workers in Coating Plants. They are perceiving the risk related to hazards only when there is an visual input as overspray, or dirt of paint on themselves. There so we offered VOC (Volatile Organic Compound) sensor equipped device that gives a real - time visual and tactile feedback to workers about the level of hazards.

Technological potential, or the potential of technological devices (i.e. Assistive Technology) is in the possibility to give objective data to the user and an immediate feedback, instead to rely on subjectivity of our own senses. Another added value of technology implementation lies in the fact that in this way there is a possibility to arrive to perform both on individual and social lever, and on social participation of individuals.

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