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# Internet of Senses (IoS) and Internet of Sensory Health (IoSH): A New Technology Epiphany

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## ABSTRACT

When a new technology emerges, it can substitute the obsolete one, or can unveil a new quiescent meaning, related to new possible uses/applications of this technology that are manifested with what Roberto Verganti calls a 'technology epiphany'. Recent reports are predicting that the greatest innovation in technology for 2030 will be the swift from the concept of Internet of Things (IoT) to the concept of Internet of Senses (IoS). The goal of this paper is to define with the term Internet of Sensory Health, a possible technology epiphany for the emerging Internet of Senses, related with the application of these technology in the health field. The topic will be addressed with the use of Verganti's framework for innovation strategy, and with the discussion of a case study, in the field of Synesthetic Design for Health and Wellbeing.

**Keywords:** Internet of Things, Internet of Health Things, Internet of Medical Things, Internet of Senses, Synesthetic design, Design for health and wellbeing.

## INTRODUCTION

The concept of Internet of Things, also known with the synonyms 'web of things', 'internet of objects', 'connected devices', has been defined as:

*"An open and comprehensive network of intelligent objects that have the capacity to auto-organize, share information, data and resources, reacting and acting in face of situations and changes in the environment"* (Madakam et al., 2015).

From the beginning, the concept of Internet of thing have been very focused on technology, rather than on people's needs. Historically, the first connected object was a coke vending machine at Carnegie Melon University in 1982. As soon as the Internet was created the intention of connecting more 'things' together was manifested: in 1990, a year before the launch of the World Wide Web, John Romkey (Founder of FTP Software) & Simon Hackett connected a bread toaster to the Internet.

Despite these pioneering experiences, the term 'Internet of Things' (IoT) was used for the first time in 1999 by Kevin Ashton (at that time the Executive

 

Director of Auto-ID Labs in MIT) in a Presentation about RFID, a breakthrough technology for that time (Ashton, 2010). From that moment, the development of sensors and micro-electric devices, the diffusion of smartphones (iPhone, 2008), and the improvement of the communication infrastructures (3G, 4G, and then 5G), allowed the creation of new digitally identifiable and mutually connected objects, able to "*interact with each other and with the external world by exchanging data over the existing Internet infrastructure*" (McEwen & Cassimally, 2013) (Vitali et al., 2016). In 2008 the number of connected objects surpassed the number of people on Heart.

## From Situations and Changes in the Environment of Health Things: A Technology Epiphany

With the re-elaboration of the Internet of Things known as Internet of Everything (IoE) (Cisco®, 2013) the network is no longer composed only by objects and data, but people were for the first time considered the nodes of the network.

The success of these devices in field as smart-home, smart-cities, and in smart-health, is the result of the identification of new meanings applied to breakthrough technologies. According with Roberto Verganti: *"when a new technology emerges, it can simply substitute the obsolete one, by keeping the existing meaning […] or can "hide" a more powerful quiescent meaning* - related to new possible uses/applications - *that is waiting to be uncovered*". (Verganti, 2009) This manifestation of hidden meanings has been defined by Roberto Verganti (Professor of Leadership and Innovation at the Stockholm School of Economics and Harvard Business School) with the term *'technological epiphany'* and it helps companies to discover the technology full value and to create products or services that are considered more meaningful than the current ones.

For example, the terms Internet of Health Things (IoHT) or Internet of Medical Things (IoMT) describes all the applications of the IoT technologies for medical and health related purposes. The development of IoHT devices (e.g. pacemakers, smartwatches, hearing devices, sphygmomanometers, etc.) allowed the possibility of interconnecting medical devices for monitoring remotely general health parameters for heart-related diseases, diabetes, etc. (e.g. blood pressure, heart rate, glycemia), making remote diagnose (i.e telemedicine), and generating of emergency notifications (e.g. fall detection for elderlies). The above-mentioned innovations allowed the local health Institutions to reduce the hospital-related costs.

From an economical perspective, if the Internet of Things (IoT) Market size was estimated around \$310 billion in 2020 (and is anticipated to reach around USD 1842 billion by 2028), the market of Internet of Health Things market was estimated around \$30.79 billion in 2021 (the 10% of the IoT market) and is projected to grow from to 187.60 billion in 2028. (Fortune Business Insights, n.d.). If IoT technology represents a technological advance, with the definition of Internet of Everything and the subsequent Internet of Health Things, a new use of these technology

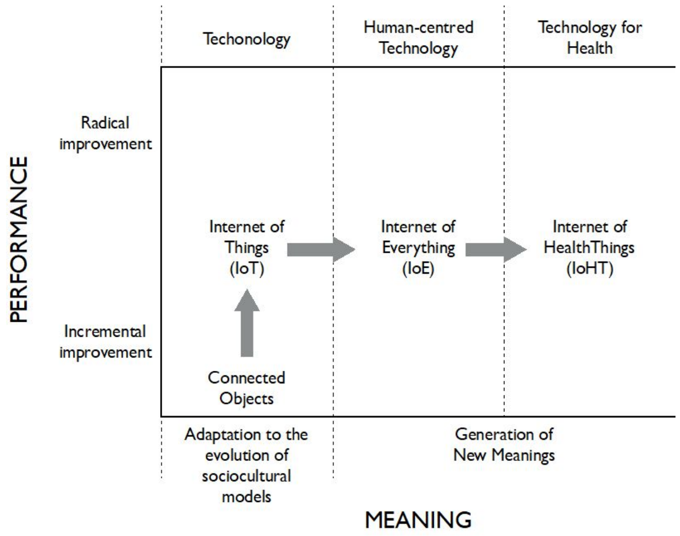


**Figure 1**: Verganti's framework for innovation strategy applied to IoT, IoE and IoHT.

was found, and a new meaning was unveiled. We can describe this process using Roberto Verganti framework for innovation strategy (fig.1) (Verganti, 2009):

## Internet of Senses, a New Breaktrough Technology is Emerging

*"Imagine an immersive experience of a beach where you can feel the wind blowing on your face, the heat of the sun on your back, the humidity of the ocean air on your skin, and experience the fresh smell of the ocean breeze - right into your living room."* (Ericsson, 2020).

Current audio-visual and haptic devices are already allowing people to have digital experiences very similar to the physical ones. According to a recent report (Sony Ericsson, 2020), the biggest trend for 2030 will be the creation of an Internet of Senses: a new technology paradigm in which digital experiences will become more multisensory and therefore fully immersive. In this scenario devices, sensors, and networks, supported by a large use of Extended Reality (XR), will merge the digital and the physical reality, involving all our senses. These experiences will be possible thanks to the new generation of connected devices and sensors, that will be able to:

- improve the quality of XR experiences (supported by holographic representation)
- introduce new sensory experiences as digital flavors and digitals aroma.
- create new interactions will be created using brain-computer Interfaces.

At this point a question naturally arises: *how can we apply IoS technology to human-factors?*

From a design perspective, the development of IoS technologies opens interesting scenarios for multi-sensory and cross-sensory design approaches in Human Centered Design. Particularly interesting is the possible contribution of these technologies for Synesthetic Design.

Synesthetic Design is a field of research that studies the systematic connections between the different sensory modalities. How? When we interact with a stimulus (let's imagine a smell - or a digital smell – of a pizza) we recognize that it doesn't trigger only the sensory system which has been directly stimulated (in this case the olfactory system), but also other senses that, even if they are not directly stimulated (i.e gustatory system), contribute to provide a more complete information about the stimulus (a perception of the taste of the pizza). Synesthetic Designers study and design these correlations/contaminations between different modalities. Indeed, *"any designed stimulus is able to solicit, refer to and interact with the whole concomitant information modifying the intrinsic nature of stimuli"* (Anceschi & Riccò, 2000).

The effects of stimuli are evaluated within the specific sensory modality (the main sense triggered by the solution) or in correlation with other modalities. The main objective of Synesthetic-Design is to achieve the optimal configurations, based upon the systematic connections between the modalities (Haverkamp, 2013), Synesthetic Design approaches have been successfully used in various fields of design: from inclusive design (creating accessible design for blind people) to communication design, from Automotive Design to Design for Health and Well-being.

## Internet of Sensory Health (IoSH): A New Technology Epiphany?

In the UX/UI Lab of UNIDCOM/IADE, Universidade Europeia of Lisbon, we imagined a new meaning for IoS, technology (fig. 2), analogously to what happened with Internet of Health Things (IoHT) and Internet of Things (IoT):

*if health has been a successful strategy for generating new meanings for Internet of Everything (IoE), can health be a successful strategy for generating new meanings for the Internet of Senses?*

The Sensuous Project is a current study in which we are exploring the possibilities of using a synesthetic design approach to create an immersive multi-sensory experience (fig.3), with the use of current IoT devices, with the aim of evaluating the impact of concomitant environmental sensory stimuli on **pain perception**.

The study consists of a 4x2 within-subject design study based on a Cold Pressor Test, involving 42 participants.

The effects of sensory stimuli on pain perception have been demonstrated with studies involving concomitant sensory stimulation in different modalities, proposing **mono-medial** interventions to distract, motivate or create counter-irritations that might reduce pain, involving concomitant sensory stimulation in different modalities:

- Tactile (Boensch, 2011; Chen & Johnson, 2010; Riley & Levine, 1988)
- Acoustic (Basínski et al., 2018; BURT & KORN, 1964; Garcia & Hand, 2016; Gardner et al., 1960; Gardner & Licklider, 1959; Howitt & Stricker, 1966; Mitchell et al., 2006; Morosko & Simmons, 1966)
- Visual (Rahimi et al., 2013)(Yousuf Azeemi & Raza, 2005)

Considering that every stimulus in the environment is likely to be designed (Rognoli et al., 2016) and considering that the design of each stimulus produces effects in other sensory registers (Riccò, 1999, 2008) it was decided to

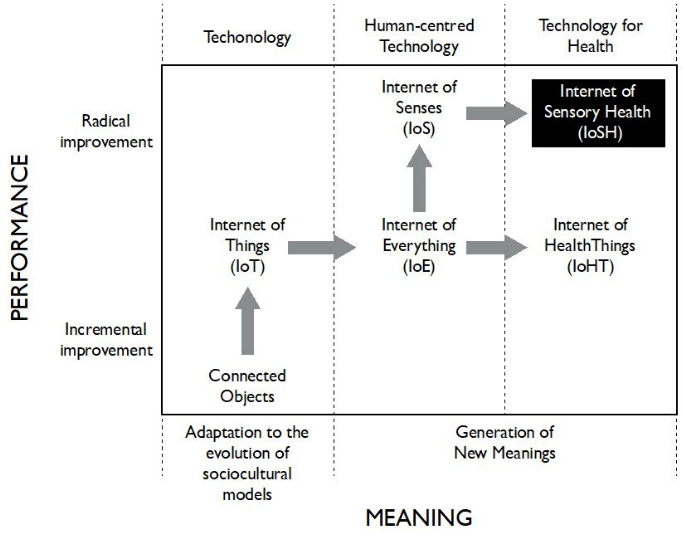


**Figure 2:** Internet of Sensory Health as a technology epiphany.

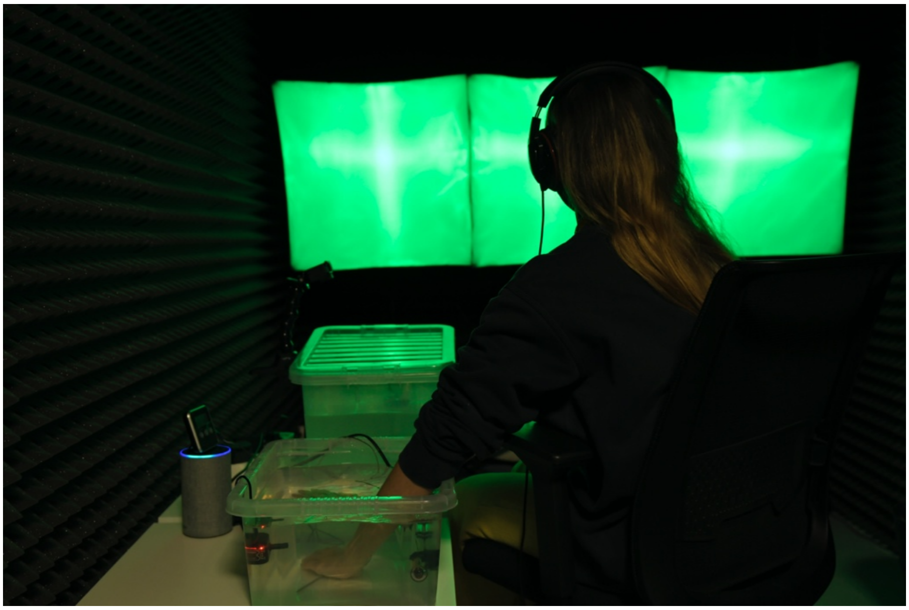

**Figure 3:** A picture of the experimental set-up of the sensuous project.

use a Synesthetic design approach to create a **multi-sensory** immersive experience. The objective of the study is to identify which sensory combination between stimuli of different modalities could have a stronger impact in terms of analgesic effects.

## DISCUSSION

Internet of Senses represents a breakthrough technology for the next years. The diffusion of IoS device may lead to new innovations of meaning regarding new possible uses/application of these technologies.

In this scenario, the diffusion of IoS technologies for immersive multisensory experience opens interesting scenarios for the development of sensory-based strategies unveiling new quiescent meanings regarding the promotion of peoples' health. We could define this technology epiphany with the term 'Internet of Sensory Health' (IoSH).

Some possible IoSH scenarios are:

- IoSH technologies for the remote treatment of chronic pain conditions (e.g. fibromyalgia; phantom-limb pain; etc);
- IoSH technologies for pain management in specific hospital divisions (e.g. post-surgery care; labour rooms, dental surgery, etc);
- IoSH technologies for promoting relaxation in people with autistic spectrum;

In general, the adoption of a Internet of Sensory Health technology could be a strategy to humanize healthcare settings, generally considered stressful, chaotic and unpleasant places, (Ulrich, 1991, 2000, 2005; Ulrich et al., 2008) adopting a Synesthetic Design approach.

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