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Multi-layered functional analysis for smart homes design

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Abstract

The conception of smart homes exceeds the boundaries of a simple design process. It becomes mainly a managerial, multidisciplinary process in which added value depends on the measure in which these answer, in an adequate manner, to a set of requirements raised by a target group of users and stakeholders with specific needs.
The paper proposes a methodology for functional analysis of smart living spaces that combines a multi-level approach for its structure with FAST (Functional Analysis System Technique). A generic functional scheme for a smart living space is defined and explained, and then, for illustrative purposes, this scheme is customized for the functional analysis of two smart systems of the mentioned space: illumination, and safety/security.

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Keywords: Smart homes, Functional analysis, User oriented development

1. Introduction

In today's economic world the design and development process is bound to cope with the pressure to continuously improve products and services. The architectural and construction fields are no exception in this respect. Increasing customer and user demands and market competition, raising requirements for sustainability and inclusion, plus the rapid progress of knowledge and technology, all together lead to an increase of the complexity and, implicitly, of the difficulty of decisions in the mentioned field (The World Bank 2015)

In the actual architectural and urbanistic landscape, smart technologies are more and more present both at the large-scale of smart cities (National League of Cities 2017) that are using ICT for building an infrastructure to continuously improve the collection, aggregation, and use of data to improve the life of their residents", at the medium scale of smart buildings, able to adapt their characteristics and facilities for optimizing the energy consumptions and functional costs, and at the small scale of smart spaces and smart objects, highly connected and capable to interact in an intelligent way with the life of their inhabitants.

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A smart living space and its component objects have the ability to fulfill multiple and complex functions, to process complex information, to communicate with the residents, with each other and with people or equipment from the outside, to learn from events and to take autonomous decisions in certain situations having the objective to protect or facilitate the everyday life of those who live there. Such attributes, when associated with the home space, nominates it as intelligent or smart.

The approach in conception and development of such smart homes far exceeds the boundaries of a simple design process. It becomes mainly a managerial, multidisciplinary process in which many different types of skills (space and form architecture, functional design, software development, communication systems and others) converge to generate solutions that are able to meet the needs and requirements of certain target group of users and stakeholders.

The added value of such a solution comes from the functions offered by the living space and the measure in which these manage to answer, in an adequate manner, to a set of requirements raised by a specific need (e.g. those of a person with certain disabilities). In this context, function identification and analysis becomes a critical component for the resulted value of the entire design-development process.

The paper proposes a methodology for functional analysis of smart living spaces that combines a multilevel approach for its structure with FAST (Functional Analysis System Technique). A generic functional scheme for a smart living space is defined respectively explained, and then, for illustration, this scheme is customized for the functional analysis of three smart systems of the mentioned space: illumination, shading, safety and security.

2. Background

The present paper intersects two conceptual spheres that are required to be briefly presented and explained to provide a knowledge base for the subsequent presentation of the specific contribution. These two concepts are smart spaces (particularly smart homes) and functional analysis.

2.1. Smart living spaces

Starting from the characteristics of human intelligence that some associate with the individual adaptive capacity (Sternberg & Salter 1982; Binet 1905) and the ability to acquire, store, combine, compare and use information in new contexts (Humphreys 1979) along with the maturation of ICT (Information and Communication Technologies), direct correspondences between the characteristics of human intelligence and the characteristics of modern technologies can be identified. (Acampora et al. 2013) identify for all smart living spaces a number of common features:

- *Context aware:* exploiting the contextual information;
- *Personalized:* to the individual needs;
- *Anticipatory:* anticipating the individual needs without a conscious intervention.
- *Adaptive:* to the changing needs;
- *Ubiquitous:* integrated into the everyday environment.
- *Transparency: e*mbedded in an unobtrusive way in the daily life.

The first mention of "smart house" dates back to 1984, being linked to the name of a working group of the US National Association of Home Builders, aiming to advocate for the inclusion of automation in home design (Aldrich 2003). The modern intelligent house, however, takes shape only from the beginning of 21st century, once the involved technologies (processing power, miniaturization, integrated systems, communication technologies, etc.) reach the required maturity. Being an emerging field, "intelligent houses" and their definitions are very varied in the scientific literature, but one cannot yet identify a comprehensive and universally accepted definition. However, to provide an overview, one can consider a smart living space, a ubiquitous processing application (Alam et al. 2012), which integrates advanced sensory, communication, automation and control technologies (Vimarlund & Wass 2014) to form a smart and context aware system (Alam et al. 2012), which anticipates and adapts to the needs of residents to enhance their comfort, safety and entertainment (Aldrich 2003), energy efficiency (Saad al-sumaiti et al. 2014) and health (Reeder et al. 2013).