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Consumers vs Internet of Things: a systematic evaluation process to drive users in the smart world

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Abstract

Smart Objects (SOs) market offers a wide variety of products apparently similar but characterized by different features that the average users fail to perceive. Consequently, their purchasing is often based on price and brand affection. In this context, users need a tool able to guide them in choosing the most suitable object to satisfy their expectations. To this purpose, this paper proposes a new systematic method to assess SOs in a comprehensive way: it allows to objectively assess and compare products and provides evaluation results tailored on users' needs. A first validation is carried out on three different SO typologies.

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Keywords: Internet of Things, Systematic evaluation process, Usability, Smart objects

1. Introduction

The world has entered the age of the Internet of Things (IoT), where technologies have reached a maturity that enable each electronic device to be connected [1]. The market of Smart Objects (SOs) is increasing rapidly, from wearable technologies to telemedicine systems and home automation devices; a large amount of new connected devices is coming out in the global market. Despite this trend, there are still barriers that limit the mass dissemination of such technologies. While cost has historically been the most significant barrier to smart systems adoption, in the last years new obstacles have emerged raising consumer concerns. One of the major obstacles is the accessibility of the average user to these technologies.

Turning everyday products into connected products and linking them creating an ecosystem is a complex process. In fact, producers are usually strongly technology-oriented and aim to increase the potentiality of their products and systems neglecting the consumers mistrust towards smart technologies and innovations in general. While technology and logics behind a smart object are complex, the user's experience must be easy and intuitive. In this context, it would be fundamental to adopt a User Centred Design (UCD) approach in order to develop user-friendly products with features understandable by the average user, leading consumers toward the acceptance of these new technologies. Indeed, it has been demonstrated that generally people's perception of system qualities mostly depends on how they interact with it: how easily they understand the way it works, what they feel about it, how much it serves their purposes and fits in the context of use [2].

In addition to this, the constant evolution of Information and Communication Technologies (ICT) and the lack of common technological rules (communication protocols, physical connections, etc.) have led companies operating in the IoT sector to develop and promote its products and services independently. This condition has generated a market that quickly increased the number of companies and devices available to consumers [3]. Consequently, the customer has to choose between a wide variety of products apparently very similar, but each of them hides different features that the average user often fails to perceive.

In this context, it is important to give to the user a tool that can guide him/her in choosing the object able to satisfy his/her

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needs and expectations. In fact, the success of a product or a service is mainly due to its ability to meet the user needs by providing what he/she exactly wants. For this purpose, this paper will present a systematic, flexible and innovative experimental protocol for the evaluation of smart objects that allows assessing and comparing different technologies from a technical and usability point of view. It has been validated by means of an experimental case study focusing on three different SOs belonging to different categories: body scale, blood pressure monitor and IP camera.

2. Research background

Smart Objects (SOs) can be defined as everyday consumer products equipped with sensors, memory and communication capabilities [4, 5], which are able to capture information about their surrounding, communicate with each other and react according to specific rules [6], help users to understand the behaviour and capabilities of their products and allow them to accomplish their tasks in a new intuitive way [7].

Based on our knowledge, although there are some studies that propose methods to assess SOs functionalities according to user needs [8, 9], no studies have been yet conducted with the aim to define a systematic method to objectively evaluate SOs overall quality in order to assist consumer in purchase decision. To help consumer in SOs selection, it is necessary to evaluate and compare them according to their ability to support specific users' goals.

As SOs are interactive devices, this means, on one hand, to consider their technical and functional features (e.g., material, connection technology, interoperability, reliability, accuracy, price, etc.) and evaluate them with respect to customer requirements. To this purpose, Quality Functional Deployment (QFD) is the best approach, among those proposed in literature. QFD is a systematic methodology for quality improvement and product development, originally defined in 1972 at Mitsubishi's Kobe shipyard site [10]. Several studies report its effectiveness in benchmark analysis [11].

On the other hand, it is necessary to assess SOs human-machine interaction quality. If we consider a product only from an instrumental point of view, the quality of a product perceived by a user during interaction can be measured by assessing usability. Usability is "the extent to which a product can be used by specified users to achieve specified goals with effectiveness, efficiency and satisfaction in a specified context of use" [12]. In literature, there are many usability assessment methods that require users involvement or that are based on expert judgments. Among expert evaluation methods, evaluation based on Nielsen's heuristics [13] is the most common one. Meguire [14] provide a review of main methods for test usability with users.

However, usability is not sufficient to cover all the relevant aspects to assess the overall user-product interaction quality. According to Norman [15], product design affects users on three levels of information processing: visceral, behavioural and reflective. In particular, there is a dependency between aesthetic impression of a user interface and its perceived usability [16]. According to the Standard ISO 9241-210 [17], User Experience (UX) is "a person's perceptions and responses that result from the use and/or anticipated use of a product, system or service".

Consequently, UX can be considered as the result of all user emotions, beliefs, preferences, perceptions, physical and psychological responses, and behaviours that users experienced during interaction with a product (i.e., before, during and after use). Several methods can be used to evaluate UX: they range from extensive observation studies to more quick and dirty methods, such as interviews and questionnaires [18]. Among the second ones, the AttrakDiff questionnaire [19] and User Experience Questionnaire [20] are widely used for quick assessment.

Based on our knowledge, no systematic approaches have been defined to assess SOs quality in a comprehensive manner.

In this context, the present research aims proposing an approach to assess SOs from all perspectives.

3. Methodology

In order to increase the consumers' awareness about the IoT world and provide them an efficient tool to discover and compare products, an objective protocol to evaluate SOs has been developed.

Such result has been obtained by defining and adopting an approach that consists in the following six main steps:

1. Market analysis and definition of common patterns of connected devices;
2. Literature and standards analysis to identify what aspects should be taken into account in an evaluation process;
3. Creation of the experimental protocol structure in terms of aspects to assess and criteria for the score assignment, according to the results of the previous steps;
4. Definition of specification documents and procedures that describe how to perform the UX analysis and the tests aimed at the technical evaluation of a specific parameter;
5. Analysis of users' needs and correlation with the evaluation protocol items in order to ensure the protocol adaptability and satisfy the users expectations;
6. Experimental protocol validation by means of the involvement of experts.

The main evidence, originated from the Step 1, is the importance of the data collected and elaborated by SOs. Indeed, it is a peculiarity of smart devices as well as the connectivity requirements and specifications. In addition, interoperability and the offered services are two other significant issues to be considered. Furthermore, it is worth to specify that standard aspects such as the quality, reliability, price, and usability, which are common to the majority of commercial products, cannot be neglected.

Step 2 highlighted the existence of several guidelines to verify if products respect the quality standards, to assess the user experience and to test their reliability. However, evaluation protocols focused on other parameters such as products features, technical specifications, etc., are still missing. This is often due to the specificity of these aspects. However, feedback about them are more appreciate by consumers, as emerged from an analysis of the most important review websites and blogs.