Interaction with a personalised smart space for enhancing everyday life

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Abstract. In the last years the interest for designing and implementing smart spaces grew significantly. Many researchers adopted a top-down approach, focusing on embedding smartness in buildings, objects and everyday artefacts. In my research work I propose the adoption of a user-centred design approach to reach a new definition of smart spaces based on people's needs and requirements. The main goal will be the definition of a new interaction paradigm supporting natural and spontaneous ways of exchanging information between people and their surroundings.

1 Introduction

The concept of smart space characterizes a physical place where people and technologies cohabit and continuously exchange information in order to create an interactive space where people's needs and requests are satisfied in an intelligent way. Focusing on the importance of space in people's everyday life, there are several studies that highlight how human beings establish a deep relation with the physical environment in which they live and how, in turn, the environment influences the creation of their own identities and personalities [20]. Being part of a space stimulates the creation of an emotional bond and a relationship based on the exchange of information and feelings with what is occurring in there.

Introducing technologies in everyday environments makes it harder to maintain these relationships. However, there are many authors interested in introducing technologies in spaces in order to make them smart. In this view, they adopted a top-down approach to characterize a smart space. However, this approach emphasizes the distance between people and space and makes it impossible to maintain an authentic relation between people and space. I propose the adoption of a user-centred design approach to achieve a new characterization of smart spaces based on people's needs and requirements and in which smartness is related to the capability of creating a personalised space that enables a deeper and emotional bond between an individual and the space itself.

The main aim of this work is to characterise a personalized smart space (PSMA) as a an entity where human bodies, the space itself and the smart objects in it create a real interactional network which can increase the quality of everyday life according to the needs, preferences and requirements of each human being that lives inside it.

2 Pillars

A PSMA is the setting where a plethora of different intelligent components with various capabilities and levels of smartness live and cooperate, a complex system created by the interrelation of people, places and objects.

Body. Traditionally, the body can be considered as a referent to construct adapted spaces and buildings [15]. Designing the Vitruvian Man, Leonardo da Vinci suggested to adopt the body as a measure of everything (e.g., inch and feet units in the imperial system), using the proportions of the body as instruments to identify a space that is best suited for humans.

Moreover, the body already presents a set of *special tools* for interacting with the environment: the senses [14]. Human experience starts from them: touching, smelling, hearing, tasting, seeing, exploring the environment with the senses, building knowledge about it. According to the theories of embodied cognition and embodied space, knowledge derives from the coupling of *action* and *perception*, exploiting the experiences generated by the continuous interactions between the body and the environment [4]. Nowadays, there is an increasing interest in rediscovering bodies [5], senses [18] and gestures[7] in order to achieve new interaction models to experience the surrounding environment.

Space. I would like to consider a space as a composite place, where people, objects and physical space cohabit.

Currently, a smart space (SMA) is defined as a place enhanced with digital capabilities. Bringing one step further the considerations about body and space in Section 2, we can analyse the role that the body plays in defining the space. The human represents the main component in the process to describe and organise the surrounding environment. Stressing the importance of the bond that people can establish with the space and exploiting body as the main element to keep in contact with the environment, I intend to reach an innovative definition of SMA based on the perceptions of space from a user-centred perspective, taking into account the potentiality that humans have to interact in a SMA. We will refer to this notion as Personalised Smart Space (PSMA).

Objects. Objects represent instruments designed to accomplish a task. First, objects extend human capabilities, improving and/or augmenting her common abilities [19]. Second, objects embody what people can do with it [6] [16], as an interface that enables actions and usages according to the affordances that it offers. Going towards the *Ubiquitous Computing paradigm* [21] and Internet of Things (IoT) era, smart physical objects (SPOs) are able to act in the environment and to connect to the Internet. SPOs are the combination of two main components: a physical layer including a controller and a set of sensors, actuators and communication capabilities and a digital layer that enables to manage their behaviour in the context of use [13]. SPOs can be characterised by different levels of smartness: from the ability to exchange information with people and other smart objects, to the ability of managing knowledge about themselves, their role, scope and relation in the surrounding environment [1] to the ability of learning from experience [17].

3 Goal and methodological approach

The main goal of my work is to define the novel concept of PSMA as a complex system where body and SPOs cohabit in a shared experiential space with a continuous exchange of information, collaboration and negotiation between them according to the needs of each individual. Using a user-centred approach, I intend to support the idea that not only is a PSMA defined by the intelligence embedded in it, but it is especially characterized by the capability to adapt in order to accomplish the individual needs, preferences, requirements of each single user, becoming her personal PSMA, able to reflect her personal experiences.

In order to characterize a PSMA and to introduce new paradigms of interaction with it, I will take two different methodological steps: first, I will characterise a PSMA as an SPO, or better as a composite SPO, in which the combination of SPOs with different levels of intelligence gives it an higher level of intelligence and responsiveness to users' needs; second, adopting user-centered design, my focus would be on people who will play a central role in the process of defining the intelligence of the space. Body will be used as an interface and senses would be the principal instruments for exploration of the space.

3.1 First step

Defining smartness. In order to characterize smartness in a space, we need a classification of smartness in objects. An SPO is a combination of a physical and a digital layer; the latter can be described as a set of computational functionalities that enhance its abilities yet preserving its physical aspect. Many dimensions can be taken into account in order to characterise intelligence in an SPO. First of all, smartness can be regarded as the awareness about its roles and goals according to different contexts of use. Second, it is related to the ability to interact with humans and other SPOs that constitute the surroundings. Third it can be related to the ability of making inferences and of learning from experience. In summary it can be related to the interactional and problem solving capabilities of an SPO. The highest level of intelligence can be reached with the ability to change its behaviour according to contextual situation, supporting a continuous and active exchange of information and states between the SPO and its surrounding [8]. The final goal is to introduce a strong characterization of SPOs describing their abilities and their problem solving capabilities in a contextual situations.

Coding the smart space corpus. Given the characterization of SPOs, I will characterize a SMA as a composite SPO, whose intelligence derives from the aggregation of the level of intelligence of the composing objects. I expect that the level of intelligence of the SPO is more than the aggregation of its components. I estimate the following main results. First, I will provide a framework following designers to describe how a SMA can be obtained taking into account each component that could be inside it and the minimum level of smartness that it should have in order to be active and proactive with the surroundings. Second, I will provide an innovative corpus supporting people's interaction with a

smart space. The main idea is to create a coding of space components (objects, space, people) in order to define a framework to represent SMAs and to support the communication between the components in it and the negotiation of their actions.

3.2 Second step

In the second step, I will focus on human beings and their interaction with the surroundings. As already explained in Section 2, a PSMA can be characterized as complex customized system capable of reshaping and modifying itself for responding to the personal demands of each single individual.

In order to achieve this goal, my plan is: first, to take into account user's needs in order to transform a SMA into a PSMA able to respond to them; second, to design a new interaction paradigm that allow users to exchange needs and information with the environment in a more natural and spontaneous way.

Mapping user's needs. In order to map the user's needs, I will borrow techniques from user adaptive ubiquitous systems that are able to adapt their behaviour and interaction based on user's features and the context. These systems rely on representations of users (User Models) [2] that can provide a complete picture of each user with her features, habits, preferences, behaviours and activities. Exploiting these models, they can support the selection of a set of appropriate services adapted to the user's features. A PSMA can result from the combination of user modeling and adaptation technologies with the functionalities offered by a SMA in order to provide services personalised to user's features, place features and SPOs.

Designing a new interaction paradigm between people and spaces. The emergence of a PSMA able to know, understand and predict user's needs, preferences and requests, will allow a user to interact with it without additional effort.

Bypassing the traditional interaction model (Fig. 1), the increasing adoption of wearable technologies opens new opportunities, offering an interaction with surrounding spaces that needs a minimal effort from the users. In fact, wearable computing allows user to use her own body to get in touch with the environment.There is a growing interest in designing new natural interaction models, using gestural interaction and a *body in action* according to the embodied cognition theory and its applications [3]. The exploitation of the richness of the body, of the senses and of the movements considers actions as the most relevant part of cognition [4]. As a result, the growth of studies about full-body interaction restores the importance of the body as a controller able to move with several degrees of freedom and, at the same time, as an interface to exchange information with the surrounding environment.

As a consequence, there is a huge space of new perspectives for the design of ubiquitous natural interaction exploiting the body and senses, taking inspiration from the matching between the capabilities offered by innovative technologies such as wearable computing, tangible interfaces and the renewed interest in body and senses (Fig. 2).

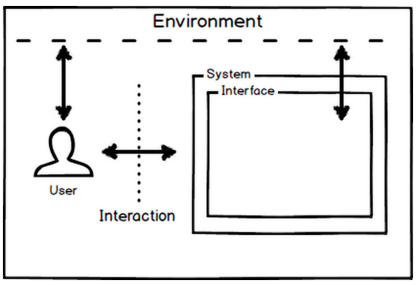

Fig. 1: Traditional interaction

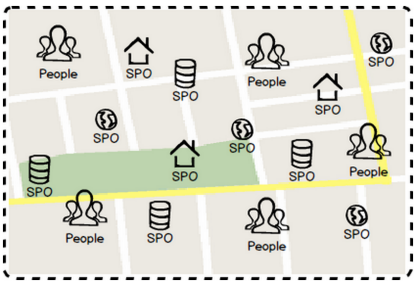

Fig. 2: Interaction in PSMA

4 Status of current research

The current status of my research project is as follows: I analyzed what an SPO is and in particular how intelligence can be characterized, decomposing it into several dimensions, discussing and analysing a notion of "granularity of its intelligence" [9]. I then introduced new affordances to communicate the augmented functionalities of SPOs [12]. I introduced natural interaction paradigms for spaces, focusing on wearable computing [11], full body experience and multisensory experience [10]. In this way I explored the body as a natural interface to keep in contact with the surroundings. Next steps will be toward understanding new frontiers in natural interaction in spaces.

5 Research directions and future steps

The main aim of my work is twofold: first, choosing a set of new interactive tools that stimulate a natural interaction in the spaces allowing a continuous exchange of information between people and a SMA in order to create a PSMA; second, designing a new interaction paradigm to support a direct interaction with spaces exploiting body as a natural interface and adopting gesture and senses as the only tools to accomplish these tasks.

The interaction in a PSMA could be based on a new code as a corpus to exchange information in user-friendly way with the environment (Fig. 2). The constant exchange between descriptions of people derived from user models and capabilities and knowledge embedded in a SMA will allow us to build a new concept of PSMA completely based on the user features, needs and preferences, without any mediation in interaction. This will allow people to interact using their body in a more spontaneous way and allow each one of them to build her own PSMA.

Taking inspiration from the steps already defined in Section 2, the ultimate goal will be the definition of a spatial framework based on these components and able to provide a set of instruments and guidelines to build a PSMA starting from the definition of the space itself.

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