Empowering Users in the Time of the Internet of Things and Robots

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ABSTRACT

Most objects of our daily life can be connected. Such objects involve a variety of sensors and actuators that enable the possibility to detect many possible types of events and conditions, which can be monitored to control the behaviour of applications, objects, and devices. One of the main challenge is how to give power to end users to configure access to smart future environments, consisting of hundreds or thousands of interconnected devices, objects and robots. In this position paper we discuss aspects that we consider important in this perspectives based on our experience in some projects.

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Figure 1: The IoT world..

INTRODUCTION

The Internet of Things is the network of the objects of our daily life (such as lights, refrigerators, car components, medical devices, dog collars, etc.) that can send or receive information with various devices. These objects include sensors and actuators of various kinds and can interact with each other, with human beings and with the environment to exchange data, reacting to real-world events, triggering actions and activating services. They are increasingly used in any sector: home, retail, industry, agriculture, ...

Robots can be considered as an extension of this technological trend since they are composed of integrated sets of sensors and actuators. In general, there is a distinction between industrial robots, developed to accomplish specific tasks in specific work environments, and social humanoid robots, usually exploited in environments coexisting with human beings with whom they must relate and exchange information. Thus, they can help us at our jobs, in housework, in the care of children, elderly and disabled people, in hospitals, schools, hotels and so on. Such humanoid robots interact with us by voice, gestures and all the other modes typical of human communication.

Thus, we use our applications more and more in dynamic contexts in terms of services, devices, objects, robots and people where many events can occur. The increasing pervasiveness of such technologies implies that they are more sensitive than ever to the user differences in terms of culture, abilities, interests, goals. An important goal is to find solutions that quickly support the personalization of context-dependent interactive applications by end users, giving power to end users to configure access to smart future environments, consisting of hundreds or thousands of interconnected devices, objects and robots

End-user development (EUD) aims to support people who are not professional developers to create or modify their applications so that they can better meet their requirements [4]. While in the past EUD has focused on spreadsheet applications, Web mashups, and desktop applications, in recent years, new perspectives [6, 8] in EUD have been put forward to address such emerging issues, including EUD for robots [3], given that the available robots can be programmed through some programming language, which is usually oriented to engineers and requires considerable effort to learn.

In this perspective, a possible approach is to exploit trigger-action programming [7,9] since it does not require knowledge of structured programming concepts and constructs. It mainly allows people to indicate the desired behaviour in the format IF/WHEN something happen DO action. It fits well with the emerging technological landscape, which is characterized by the presence of a wide variety of sensors that allow us to detect changes in the various aspects of the context of use. This approach can be applied in various application domains exploiting such technologies (smart retail, ambient assisted living, industry 4.0, home, etc.).

Figure 2: Sensors and Objects in the Trials.

AAL CASE STUDY

We participate in the AAL PETAL project in which we are developing a platform for personalizing remote assistance of older adults with mild cognitive impairments, with particular attention to the support of lighting systems in order to provide orientation over time and in space. These people suffer from cognitive issues, such as tendency to forget tasks/events and/or other issues, such as cardiovascular issues, reduced sight, irregular eating habits, and often increased risk of social isolation, and depression as well. The platform aims to support monitoring environment and user's behaviour, and controlling applications and devices. The users can set the functionalities of the technological support to control lights and other digital devices when relevant events occur. In this way it is possible to obtain personalized control of lights and other digital appliances, personalized warning messages issued in risky situations, and persuasive messages to stimulate the elderly in healthier habits (e.g. do more physical activity). Examples of personalized rules that can be obtained with this approach are:

- When user leaves the house and it's going to rain remind her to take the umbrella with a message on the phone
- At 9 am the humanoid robot reminds user about the medicines to take during the day
- Send a message to the caregiver when the user leaves home during the night
- When caregiver sends a message "where?" answer automatically with user location
- If the user has not done the planned cognitive exercises flash the light to remind him to continue this activity
- If the user is close to the living room and time is 4 p.m. turn on the TV

We are now in the process of organizing trials in eight homes with older adults with mild cognitive impairments distributed across various European countries. Figure 2 shows the types of sensors, objects, and devices we plan to use in such trials. Each user will have a tablet, and a smartwatch. We have selected a smartwatch that, in addition to detecting physiological parameters such as heart rate and step counter, is able to connect and communicate at the same time through Bluetooth and Wifi. This will be exploited to obtain indoor positioning with the support of proximity beacons. In terms of light we use the GREAT luminaire, which aims to provide health stimulating, biorhythm-stabilizing, high-quality light for high visual demands and creates an activating or calming room ambiance with different light scenes. The extremely high light intensity of 1000 lx at the eye level leads to effects comparable with classic light therapy within 5 hours of use. It compensates missing daylight and provides distributed light within a whole room of about 16 m2. In addition, we use various types Philips Hue lights to support similar effects in other parts of the home. Further sensors used are able to detect gas, smoke, humidity, use of objects, whether windows are open and so on.

Such technological setting is exploited through an instance of a personalization platform that includes a middleware (context manager) able to gather raw information from the various sensors and convert it in data that can be analysed in terms of logical events and conditions. In this way when the personalization rules are created by the older adults or their formal or informal caregivers it is possible to detect dynamically when they should be triggered and the consequent actions performed.

Figure 3: Humanoid robot example.

DISCUSSION

Based on our experiences we can discuss some lesson learnt and research challenges for the near future.

IoT and Robots are two sides of the same coin

Both in IoT and Robots people have to interact with sets of sensors and actuators. In both cases we are considering technologies that are exponentially expanding. Humanoid robots add a human-like appearance and behaviour that creates empathic atmospheres (see Figure 3), which facilitates user involvement and participation [3]. Tailoring environments should be able to address both technologies in an integrated manner in order to allow end users to specify the behaviour of robots and appliances based on what happens in the context of use.

Users can have difficulties in understanding the real behaviour resulting from their rules

Our experiences confirm issues indicated also by previous studies [2] concerning the possibility that users may have difficulties in understanding the actual behaviour resulting from their personalization rules. For example, misunderstanding of the difference between events and conditions can cause undesired behaviours, such as unlocking doors at the wrong time or activating heating when it is not necessary. Another issue is the possibility to generate conflicts between the rules (for example, if we have the rules “in the morning open the windows” and “if it rains close the window”, what should it happen if it rains in the morning?). Thus, it becomes important to provide users with tools able to debug their rules and indicate why (or why not) they can be executed [5].

Domain-dependent extensions

In order to facilitate the creation of personalization rules by people who are not particularly expert in programming, it can be useful to have an additional layer that provides support for creating rules that are particularly relevant in specific domains. The basic idea is that the structure of a set of rules that can be frequently used in the considered domain is already defined, and the domain stakeholders have just to specify the values for the specific case under consideration.

Integrating EUD with data-driven approaches

It would be interesting to integrate data-driven approaches with EUD in order to help users in the identification of relevant rules. In personalization platforms such as those presented in [1, 3] two types of data can be collected: data concerning the user behaviour (movements, interactions with objects and applications, ...), and contextual conditions (time, weather, light, ...), which is collected through the context manager; and data concerning the personalization rules that have been created and executed beforehand, which is collected through the personalization rule editor. In the former case a machine learning approach should be able to identify in which contextual situations it is preferred that some actions occur. Based on the historical data collected by the context manager it is possible to train a model, which is then used to provide some rule recommendation [10]. In the other case it is possible to obtain a personalization rule recommendation system based on rules previous provided. For example, by applying some collaborative filtering techniques.

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CONCLUSIONS and FUTURE WORK

The explosion of the internet of things and robots leads us to use our applications in increasingly varied dynamic contexts. Our applications, objects, robots can generate a myriad of possible events, and each user poses specific requirements about how to react to them. End users are those who should drive the behaviour of their context-dependent applications, and EUD methods and tools are fundamental for this purpose.
We plan future work in two main directions. One is related to how to evolve EUD approaches in order to address the issues mentioned in the discussion. The other one aims to investigate how data can help us to obtain mixed-initiative, usable platforms for personalization of daily environments in order to improve user experience in which some intelligent support suggests possible rules to add to those created explicitly by end users. In this case it will be important to preserve intelligibility and accountability: context-aware systems that seek to act upon what they infer about the context must be able to represent to their users what they know, how they know it, and what they are doing about it.

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