Advanced Interaction Paradigms to Define Smart Visit Experiences in the Internet of Things Era

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Abstract
The growing spread of smart objects is changing the way humans interact with technologies since the interaction they propose is more and more physical and less virtual. From an HCI perspective, one of the most interesting aspects regards how non-technical end users can program the behavior of such smart objects. This poster presents an ongoing project on three novel interaction paradigms that support the creation of smart visit experiences.

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H.5.2 **Human-centered computing~Ubiquitous and mobile devices**

Introduction
The possibility to combine thousands of sensors and actuators enables smart objects to interact with humans and environments in unlimited ways, thus opening the opportunity to make everything "smart", e.g. cars, clothes, buildings, etc. This phenomenon fostered the birth of the Internet of Things, a term coined in 2009 by Kevin Ashton to describe a system

Figure 1. The smart version of the Mouth of Truth we built for the Tyrion scenario

where the Internet is connected to the physical world via ubiquitous sensors[1].

In domains like Cultural Heritage (CH), smart objects can be installed in museums, archaeological parks and exhibitions to create *smart visit experiences,* i.e. scenario where visitors acquire CH content by interacting with the surrounding environment and smart objects included in it. However, to achieve such engaging scenarios, some issues still need to be solved.

From an HCI perspective one challenging goal regards how non-technical users (e.g. museum curators), can be enabled to make multiple smart objects interact among them. In CH the role of domain experts is currently quite limited: they can at last configure single objects that visitors bring across the CH site to receive personalized content when they reach some interactive hot spots [5]. To support the design of more effective, engaging and attractive visit experiences, novel and more powerful composition paradigms are needed to synchronize the behavior of multiple devices.

This poster presents an ongoing project that aims to provide non-technical users with interaction mechanisms to create smart visit experiences. This paper follows a work we recently carried out in the area of task-automation systems [3], where we designed a tool called EFESTO-5W for simplifying the creation of Event-Condition-Action (ECA) rules combining smart object events/actions [4]. Some studies have shown that the EFESTO-5W composition paradigm effectively guides users in establishing the behavior of multiple smart objects [4]. However, we observed that in more creative and rich contexts, like CH, smart objects are not conceived as "simple" devices exposing events and actions, but they bring with themselves their own semantics. For example, a smart card depicting an Egyptian vase is not a simple hexadecimal code that can be read by an RFID reader but represents a find dated back to a certain époque, discovered in a particular place, with an ancient name, etc. This semantics could be included in ECA rules to simplify their definition and also to trigger the access to properties that the tangible objects (not only their sensors and actuators) features in the CH site context. In order to enrich smart objects with semantics, users should be able to define a set of *sensible attributes*. To this aim, we are investigating novel interaction paradigms that allow non-technical users to define sensible attributes on smart objects in a natural and simple way. In the following, we shortly describe the preliminary design of three novel paradigms.

A Scenario of Smart Visit Experience in Cultural Heritage Domain

To better understand the meaning and benefits of a smart visit experience, in the following we report on a scenario. The main person is Tyrion, a guide of an archeological park. He typically organizes its tours by arranging visitors in groups of ten persons and going with them in the park, stopping at some of the most significant points to explain their history. Tyrion wants to enrich this format by playing a serious game during the visit. The game he envisioned is based on two types of smart objects: 1) a smart version of the "Mouth of Truth" (MoT), i.e., a Roman marble disc with a relief carving of a man's face whose mouth, according to

[1] http://www.rfidjournal.com/articles/view?4986.

legend, closes if a liar sticks his hand in it (a smart, small scale version is visible in Figure 1); 2) two decks of twenty smart cards, each depicting an archaeological find. When the tour starts, visitors are assigned to two teams that receive a deck of card. During the visit, every time Tyrion stops at a point of interest, during his narration he poses a question and asks each team to select one card they consider relevant to that question. Visitors have to put the selected card inside the MoT, whose eyes blink green if the card is right and blink red otherwise. In addition, points are assigned/removed to each team depending on their answers. At the end of the game, the winning team wins a park souvenir.

Toward Advanced Interaction Paradigms to Program Smart Visit Experiences

To create smart visit experiences like the one described in the Tyrion scenario, end users need to program the behavior of smart objects by defining ECA rules. For example, to determine when a smart card is correctly read by the MoT, a rule like the following has to be created by using EFESTO-5W:

IF *(read smart card code is = AB123456* AND *MoT GPS position is lat=12.3456;long=12.3456)*
THEN *the eyes of MoT blink of color (0,255,0)*

The syntax for rule definition is far the end-user language since it refers to technical aspects, like the smart card hexadecimal code or the the GPS coordinates reached by the MOT during the visit. A more natural rule with the same behavior would be:

IF *(read smart card is = Egyptian vase* AND *MoT position is FURNACE)*
THEN *the eyes of MoT blink green*

This last rule refers to the meaning the expert gives to each smart object, in particular the smart card is associated with the name “Egyptian” instead of and hexadecimal code, while the MoT position is called “FORNACE” instead of specifying GPS coordinates. If experts can define this type of rules, representing an abstraction that speaks their language, they are facilitated in creating a smart visit experience.

The current version of the EFESTO-5W prototype lacks the possibility to define sensible attributes to be included in ECA rules. Therefore, this project aims to define novel, intuitive interaction paradigms that permit to extend the native properties of a smart object (events and actions) with custom attributes, in order to exploit them while synchronizing smart objects. The attribute definition becomes a preliminary phase that end users have to carry out before synchronizing smart objects. Given the nature of smart objects, i.e., devices with which users can physically interact through their sensors and actuators, we think that the mechanisms to define such attributes have to take into account the physicality of the interaction. In other words, traditional visual interfaces could not be adequate to define custom attributes, while more concrete and tangible paradigms can better fit the smart-objects world.

The starting point of this research was the identification of a set of attributes end users can define on smart objects. We found that data types like *string*, *number* and *geographic position* can be used to define a wide variety of significant attributes on smart objects. Starting from these attributes, we designed three different composition paradigms during a design workshop study involving 28 users arranged in groups of 5/6 participants.

Figure 2. A sketch visioning the tactile paradigm: a smart card depicting an ancient vase is on the tabletop and a set of tangible attributes are in the smart card area in order to associate some attributes.

The first paradigm is a *tangible* solution based on the use of real objects representing the three types of attributes. Initially, each group was asked to identify, for each type of attribute, at least one object of the real world whose affordance refers to the attribute meaning. For example, for the string attribute, objects like pens, inkwell and sheet were proposed. Then, they were asked to propose interaction mechanisms to combine physical attributes with smart objects. All suggestions were mediated by a mobile device. In the resulting paradigm users have to scan (e.g., by using the device camera) the smart object and then the physical attributes representing the type of attribute they want to assign, or vice versa. Each time a physical attribute is scanned, a pop-up appears on the end-user mobile device asking to define the attribute details by writing its name and value.

The second paradigm is a *pervasive* solution based on the use of the real world as source of attributes. The surrounding environment is conceived as a set of passive objects with their attributes. Let's think, for example, of a museum in which there are paintings annotated with QR-codes that can be scan with a mobile phone to read detailed information (e.g., style, painter, history). These passive objects could be exploited to copy their attributes and paste them in smart objects. During our study, each group was asked to propose, at a high level, a solution to capture the attributes of passive objects and to send them to the smart objects. In the resulting idea, a smartphone is used to explore the surrounding environment in an augmented reality fashion, but everything is visualized in black and white, except the passive objects that exposes attributes. Indeed, they are augmented with colored pins, each one associated with a type of attribute (e.g. a brown pin for a string attribute). When user approaches a passive object, its pins are enriched by their names and values, according to a semantic-zoom technique. Users can collect all the useful attributes, also editing their names/values, and then they can scan a smart object to paste the collected attributes.

The third paradigm is a *tactile* solution based on the use of a tabletop interactive display. Conversely to the previous paradigms, this solution was designed exploiting their knowledge and expertise on interactive displays [1, 2]. According to our vision, the tabletop surface is a workspace that facilitates the association between attributes and smart objects. The attributes are represented as tangible objects, for example the ones used in the tangible paradigm. To assign an attribute to a smart object, users start by putting on the surface a smart object (e.g. a smart card); afterwards, a proximity area appears around the smart object (e.g. a rounded halo) meaning that physical attributes can be placed inside it (see Figure 2). Each time a physical attribute is put inside the area, a pop-up on the surface asks user to define the attribute name and value.

Conclusion

This paper has presented an ongoing research aiming at investigating interaction paradigms that support domain experts in the creation of smart visit experiences. Three different composition paradigms have been identified, i.e. tangible, pervasive and tactile paradigms. As future work, we will develop three prototypes, each one implementing a paradigm, to be compared to assess their usability and their support to the creative design of smart interactive experiences.

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