Infoscope: A Mobile Device Supporting Exploratory and Playful Knowledge Discovery in Physical Environments

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Abstract. Infoscope is a novel mobile device that can support knowledge discovery and exploratory playing in physical environments. More specifically, Infoscope utilizes RFID technology to provide audio guiding and localized question / answer games and employs wireless communication technologies to exchange information about its user's interests with computer platforms in order to present through them related supplementary multimedia information. The device comes with two accompanying software components: one for editing / updating its contents, and one running on personal computers for providing supplementary multimedia information. Infoscope has been evaluated and tested as a museum guide and as a knowledge discovery toy for toddlers.

Keywords: Interactive museum guides, knowledge discovery toys, RFID device, Ambient Intelligence.

1 Introduction

The development of small-sized, low-cost RFID (Radio Frequency Identification) readers gave rise to their broad spread and use in combination with various types of mobile devices. RFID technology is currently used for supporting a wide range of applications, ranging from inventory management systems to museum guides and smart toys. RFID readers usually come as add-ons for personal computers, laptops and mobile devices, but a more recent technological trend dictates the integration of NFC (Near Field Communication) technology, which builds upon and extends earlier RFID systems, to smartphones. Additionally, there are several specialized mobile devices comprising RFID reading capabilities, which are mainly targeted to asset management, thus essentially complementing or replacing barcode scanners.

In practice, RFID technology constitutes a very efficient and cost-effective means for building interactive context-aware tools that support "physical browsing" [1], effectively allowing users to easily identify and retrieve digital information through physical objects and places. Two application domains where physical browsing is highly useful and can have considerable impact are: (a) electronic guides for museums and exhibition areas [e.g., 2; 7; 10]; and (b) mobile learning (e.g, [8]). In both domains, R&D efforts related to "physical browsing" can be broadly classified in two categories according to the technological approach followed:

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1. Software applications installed on general-purpose mobile computing platforms (e.g., mobile phones, PDAs, tablets); e.g. [2; 5; 7; 10].
2. Specialized devices that, following the Tangible User Interfaces paradigm [6], are explicitly designed for the task at hand; e.g. [9; 10].

Some of the disadvantages of the first category include that: (a) since the devices are not optimized for the task, they often suffer from several ergonomic and usability problems; (b) unless special precautions are taken, their users may (intentionally or not) gain access to basic device functionality (and e.g., become lost, or even alter its contents); (c) if RFID reader components are not seamlessly integrated, they can easily become detached, lost or stolen. The main disadvantage of the second category is that existing systems are mostly research prototypes offering no particular precautions or tools regarding their day to day use in a real setting (e.g., power consumption considerations, power charging procedure) or content management (e.g., adding, updating, editing). Up to now, none of the existing systems in both categories allows its users to collect information that can be browsed later on.

In addition to the above, mainly in the domain of museum guides, there has been a long-lasting "modality debate" between those supporting audio-only information provision and those opting for augmentation though multimedia, on the basis of a possible antagonism between the actual exhibits and the digital information [4; 5]. On the one hand, audio has the advantage of allowing users to look at objects while listening to description without making visual demands on their attention and not forcing them to context-switch between looking at the device and the location [11]. Furthermore, multimedia guides offer multiple choices raising problems of use, dividing the users according to their skill with portable devices [3]. On the other hand, multimedia guides can offer much richer and stimulating information, even overlaid on the real environment (e.g., augmented-reality approach [4]).

2 Infoscope

Infoscope is a wireless mobile device that can read, transmit and reproduce digital information. Infoscope integrates RFID reading capabilities and can play related

Fig. 1. Left: Infoscope industrial design (OBI industrial design patent 6003410) Right: Fully working prototype and docking station

audio information which can be adapted to its user's profile (e.g., language, age, interests). The device is embedded in an ergonomically-designed shell (Fig. 1) the industrial design of which has already been patented by the Hellenic Industrial Property Organization, while the related invention patent is currently pending.

The outer shell of the device is modeled after the shape of the earphone of antique phones. On its top side there are two buttons which are used for adjusting the audio level, a standard 3.5mm headphone jack socket and a color led providing visual feedback, e.g., when audio is playing there is a green flashing light, and when the battery level is critically low there is a constant red light. The device also integrates a small speaker allowing headphone-free use (e.g., when multiple users are sharing it). A strap can be easily adjusted around the "neck" of the device, so that it can be securely fastened around the arm or neck of its user.

Infoscope is extremely easy to use, as it mimics the use of a typical doctor's stethoscope. When a user is interested into a specific item, all she has to do is to put the device over a related RFID tag in order to listen to a corresponding audio description. Additionally, by "listening to" appropriate tags (see Fig. 2), the user can adapt the audio descriptions to her personal profile traits (e.g., language, age group. interests). RFID tags are inexpensive, highly durable and come in various shapes and sizes, allowing them to be easily integrated in diverse environments and even on (or inside) most objects (e.g., books, furniture, devices, toys). Beyond localized information presentation, Infoscope supports exploratory gaming in physical environments through question / answer games, where a tag is used to trigger a question (which is adapted to the user's profile) that has to be answered by "listening to" the tag of the corresponding place / item.

Infoscope can keep track of the RFID tags detected in each session, the order and number of times that each one was read, as well as of the answers given to the "question" tags. All this information is wirelessly transferred to a docking station, which is also used for charging the device (Fig. 3 left). The docking station communicates with an interactive application, which is installed at its host computer and can present user-profile-adapted multimedia material related to the tags read by the device, as well as the game's score and detailed information about each user's answer. Thus, this approach can provide a novel hybrid solution to the "modality debate" mentioned in the previous section.

Fig. 2. Setting the user's profile by "listening to" appropriately marked RFID tags

Setting up a space supporting knowledge exploration through Infoscope is extremely easy, fast and does not require any type of physical intervention. All it takes is to just (temporarily or permanently) attach a number of RFID tags in appropriate places. Another nice feature is that there can be multiple tags referring to the same piece of information, thus allowing access to it through diverse locations (e.g., at different heights for adults and children, or people in wheelchairs, replicated tags for crowded points of interest). New tags can be easily added to the system using a visual interface (Fig. 3 right) which supports the management and editing of the actions and profile-adaptable information triggered by it.

Infoscope can be used in various application domains where location-based knowledge discovery is needed. Up to now three "generations" of fully functional prototypes have been created and the fourth is currently under way. Each successive prototype builds upon its predecessor, improving it in terms of usability, functional, and technical characteristics, based on the results of experimental use, evaluation and testing with representative users in two application domains: (a) museum guides and (b) knowledge discovery toys for toddlers and young children.

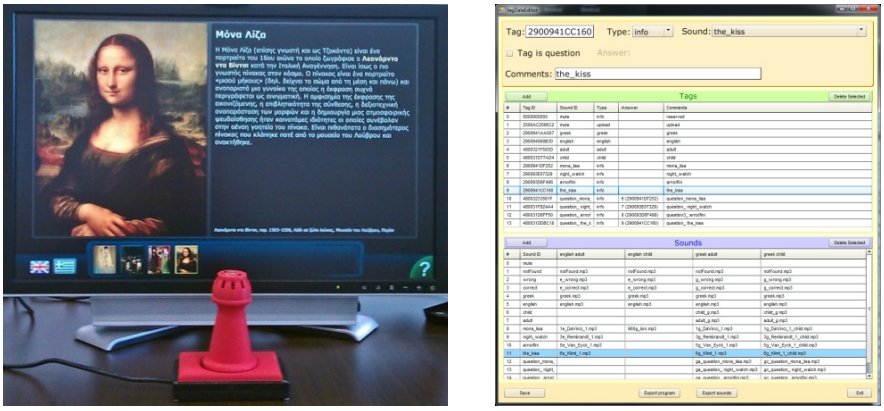

Fig. 3. (left) Docking Infoscope to its station for retrieving multimedia information. (*right*) Content editing software.

3 Conclusions

Infoscope constitutes a novel approach in the domain of mobile location-based retrieval and presentation systems, which overcomes shortcomings of previous approaches, also offering some new capabilities. Its main advantages include:

- Very simple (and playful) use by people of all ages, not requiring any experience or familiarity with computer technologies.
- Ability to retrieve information adapted to the user's profile.
- Easy and fast installation in any space, without any physical interventions.
- Does not distract the user's attention away from the objects of interest.

- "Remembers" which items were accessed by the user, and in cooperation with a personal computer can provide additional information.
- Small, lightweight, highly durable device.
- Innovative, ergonomic and functional design.
- Very low power consumption levels.
- Easy editing, update and extension of its content.
- Ability to change the shape of its shell, so that it fits the aesthetics and ambience of the environment where it is being used.
- Low production cost.

Up to now, the experimental use of a fully functional prototype for supporting knowledge-discovery tasks in various settings with representative end-users of various ages has shown that Infoscope has the potential to claim its own ground in the dynamically expanding universe of everyday mobile devices.

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