Querying and Navigating a Database of Images With the Magical Objects of the Wizard Zurlino

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ABSTRACT
This work is part of a research targeted at experimenting the use of physical artifacts for the retrieval of multimedia information. Tangible interfaces – that couple physical artifacts to digital data – are described in different research works, and a number of studies focus on tangibles for children. In spite of that, most of the work done for the kids is related to gaming or learning. This work is focused on a less explored domain, that of the access to information systems. We propose a tangible interface for enabling preschoolers to query and navigate multimedia information. The approach was tested with a class of 27 preschoolers, that where engaged in a game with the magical objects of the wizard Zurlino. The experiment gave us interesting insights about the suitability of the system for preschool children, its ease of use and the need for support by educators.

Categories and Subject Descriptors
H.3.3 [Information Storage and Retrieval]: Information Search and Retrieval; *Search process; Query formulation;* H.5.2 [Information Interfaces and Presentation]: User Interfaces - *Evaluation/methodology; Interaction styles; Input Devices and strategies; Prototyping.*

General Terms
Design, Experimentation, Human Factors, Measurement.

Keywords
Affordance, data query and navigation, information systems, physical interfaces, preschoolers

INTRODUCTION
The use of physical artifacts for human-computer interaction is increasingly gaining appreciation, as demonstrated by the success of gaming systems such as the Nintendo Wii [11]. One of the keys of the success of this category of gaming systems is related to the possibility to take advantage of the input device (i.e., the Wii Remote) for communicating gestures that mimic the use of real artifacts, such as the golf pole or the tennis pad. In spite of that, the Wii Remote can't be defined as a simple artifact, because it has a large number of programmable buttons associated to different functions, depending on the specific application. In this work we follow a different approach, based on the morphologic properties of simple physical objects. The concept of object *affordance* [7] is referred to the capability of a physical artifact to suggest – through its morphology – the possibilities of manipulating it. For example a sphere suggests to the user the possibility to rotate it. In this work we took advantage of the object affordance as the strongest cue for suggesting how to manipulate the artifacts in the context of a tangible interface, and we focused our efforts on providing an intuitive association between manipulations and digital functions. The goal was to build a system with low training needs, suitable to large categories of users – different for age and computer skills – and varying contexts of use. In this work the approach was applied to a widely diffused task, the retrieval of multimedia information through parameter-based queries and navigation of the results. In order to verify if our approach might be considered an incremental step towards universal access to information, we tested the resulting prototype with a class of preschoolers. The application of our system to a preschool environment required a consistent work for tuning the association of the different manipulations of the objects to the functionalities, for improving the multimodal design of the system feedback and for presenting to the children the concepts that characterized the interactive experience in a proper language suited to their young age. The results gave us interesting insights about the ease of use of the system.

RELATED WORK
The concept of affordance has been introduced by the perceptual psychologist J. J. Gibson [5] for referring to things that an environment offers to a person or an animal. The term has been widely applied to interface design issues. Donald Norman in [8] distinguishes between real and perceived affordances, pointing out that they play a more important role in the world of physical products than they do in the world of the screen-based interfaces, where the role of cultural conventions is much more important. Norman concludes that the *reliance on abstract representations and actions is a mistake and that people would be better served if we would return to control through physical objects* [8]. This type of control is typical of tangible interfaces that use

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the physical artifacts for accessing and manipulating digital information. The term *tangible user interface* was suggested in 1997 [6] referring to systems that augment the real world by coupling digital information to tangible objects. In the following years there have been different proposals following this concept. An interesting classification of tangible interfaces was proposed by Ullmer et al. [10], which described the importance of the relation between *tokens*, graspable physical objects that represent digital information or a computational function, and *constraints*, complementary physical objects that limit the behavior of the tokens. According to this vision, the affordance of a physical object is not defined only by the single object, but also by the complementary objects that may suggest to the user how to manipulate the primary object of interest. In recent years a number of researchers focused on tangible interfaces for children. The physical artifacts used for these experiments included simple geometrical forms such as the *Learning Cube* proposed by Terrenghi et al. [9], but also augmented toys such as jigsaw puzzles [1] and plush toys [2]. Textual languages for querying and navigating databases are typically difficult to use for most users. That is the reason why researchers have experimented alternative solutions, such as the use of visual languages or hybrid paradigms such as the *query by example*. On the web most of the search work is done using forms for composing the queries and hypertextual structures for navigating the results. Some researchers have considered the use of tangible interfaces for navigating information systems. Camarata et al. [3] propose to use a set of tangible labeled cubes for exploring an historical information database. The *Tangible Query Interfaces* by Ullmer et al. [10] take advantage of labeled objects, such as wheels, for representing continuous and discrete database parameters. Access to information systems is not usually the target of tangible interfaces for children, usually focused on learning and entertainment. Detken et al. [4] present a tangible interface based on a large number of physical artifacts for supporting children in searching and browsing books in public libraries. While interesting, the Search Wall still lacks a full evaluation about its ease of use. At our knowledge, currently there is no specific research work targeted at enabling preschoolers to query and navigate multimedia databases through a tangible interface. That is the specific focus of our work, where we tried to balance simplicity and expressivity.

THE PROPOSAL

The choice of the query and navigation task led us to define the following requirements that were used to identify specific geometries and to associate functionalities to them:

- maintaining the expressivity usually associated to the WIMP interfaces during the query phase, allowing to specify values associated to Boolean, discrete and continuous variables;
- allowing the navigation between the objects resulting from the query and the selection of specific objects, for having more information about them;
- minimizing the training needs.

In the case study we focused on a database of about 300 images, characterized by discrete, continuous and Boolean parameters: six different categories, different levels of brightness and painted in color or black and white.

Designing the input interface

The requirements specified above led us to choose the four simple geometric forms displayed in Fig. 1. For the query phase we chose the *cube*, the *cylinder* and the *plate*, allowing to select values from - respectively – the discrete, continuous and Boolean variables. Of course the selection of a higher number of values for the discrete variable would have led to choose a different regular polyhedron. The main difference with previous approaches was the decision to map the discreteness or the continuity of the variables to the number of positions that the physical objects might assume when placed on a plane (e.g., a discrete number of positions for regular polyhedra and infinite positions for a cylinder rolling over the plane). Fig. 1 shows that - for the case of study with preschoolers - the surfaces of the three objects were covered with icons representing the specific query parameters.

For the navigation phase we chose a more complex form, the *barrel*. While the manipulation of the former objects was associated to a single function (i.e., the selection of a value), the barrel permitted to manage three different functionalities: the execution of the query, the navigation between images and the image zooming. Following the research proposed by [10], we introduced three constraints for giving additional suggestions about how to manipulate the artifacts: two separate tables for the objects related to the query and navigation phases and a support for placing the cylinder on the table (see Fig. 2).

Figure 1. The artifacts for querying and navigating the db

Multimodal system feedback

We used a screen placed in front of the users for giving them a visual feedback of the manipulations and for displaying the results of the query as a navigable row of zoomable images miniatures. Besides, different abstract sounds and vocal messages were associated to each relevant manipulation of the physical artifacts.

Software architecture

Because of the space limits of this paper, we don't have the possibility to describe in detail the features of the software architecture used for implementing our system. All the components are based on web technologies, including the presentation interface based on X3D, the ISO standard for visualizing 3D objects on the net. The physical objects embedded a set of cheap Wiimote controls that were interfaced to the system using *WiiuseJ* [12], a Java API distributed under a GNU licence.

THE EXPERIMENT

The prototype was tested with a class of 27 preschoolers aged 5. The experiment was preceded by two sessions with the children's teachers that were informed about the system functionalities and the goal of the experiment. The teachers were given the opportunity to test the system with the set of tasks defined for the experiment, in order to receive suggestions. The session with the teachers led us to the decision to simplify the presentation of the images resulting from the query, switching from the first hypothesis of a grid-based scheme to a single row scheme. Such decision allowed us to simplify the manipulation of the barrel, associating its rolling to the navigation between images.

We worked closely with the teachers to translate all the technical terms into words suitable to children. The query and navigation experiment was proposed to them as an experience with the wizard Zurlino and his magical objects. For avoiding problems related to the lack of familiarity with the children, we reserved to the teachers the main task of interacting with them, limiting our intervention during the experiment to secondary support in case of problems. The experiment was structured in four steps, with the initial phase involving all the children and the following ones reserved to the interaction with the single child.

Phase 1: Initial briefing with the children

In order to grant a comfortable location for the experiment, the prototype was installed in one of the rooms where the children performed the everyday activity. The children were told by their teachers that they would have been given the opportunity to ask questions to the wizard Zurlino about the images contained in his magic bag, but that they would have been required to do it only using the magical objects disposed on the small tables placed in front of the wizard.

Phase 2: Getting in touch with the wizard

At the beginning of this phase, the single children were given the opportunity to play for some minutes with the magical objects, without a specific task to accomplish. The children were informed about the objects' functionalities but they were not informed about how to use them. The only exception to this protocol was made for the activation of the query. In order to give an initial cue for using the barrel, that was the most complex object, the children were informed that they should have dropped a magical poison contained inside the barrel for receiving their answers. The teacher that led the experiment invited the children to manipulate freely the different objects that composed the set, focusing at first on the objects associated to the query composition and then on the barrel. During the manipulation the children were invited to comment what they were doing.

Phase 3: Asking questions and navigating the answers

The children were then given two related tasks. The first one consisted in the composition and execution of a specific query, the second one in capturing and zooming one of the images resulting from the query. Each child was asked to perform three iterations of the two tasks.

During the first task (query, see Fig. 2) the teacher invited the children to perform his/her actions using simple words, such as: "Francesca, please ask the wizard Zurlino the images with the fairies, that have a lot of light and that are pictured in color. At the end, for having the answer, please drop the poison contained inside the barrel."

Figure 2. A snapshot of the query phase

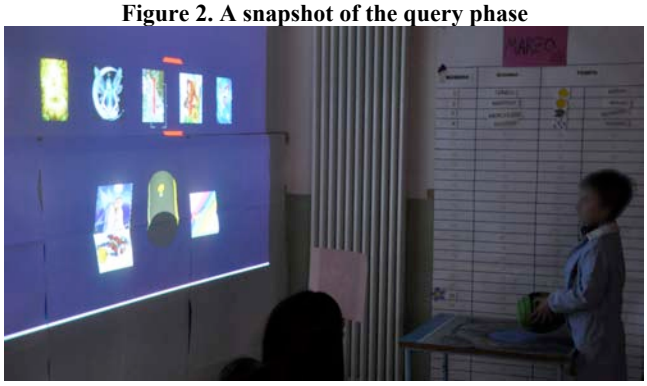

Figure 3. A snapshot of the navigation phase

At the beginning of the second task (navigation, see Fig. 3) the teacher showed to the children a printed copy of one of the images resulting from the previous query and displayed on the screen. The children were asked to capture and zoom them manipulating the barrel. The teacher used simple words, such as "Francesca, please search on the screen and capture the image that I'm showing to you, the blue flying fairy. Use the barrel to capture the image inside the red frame that you can see on the screen".

Finally, the children were asked to give a punch to the barrel to zoom the result. During the experiment, for simplifying the overall task we gave the children specific indications about the acts of pouring the barrel and punching it. For all the other cases we defined a protocol for giving the children incremental help, in the case they had problems while executing the tasks. According to this protocol the children were left free to execute the task by themselves. If the children demonstrated clear difficulties to execute the task, they were helped, at first describing to them how they had to manipulate the object and then – if the difficulties persisted – giving them a practical demonstration.

Phase 4: Final questionnaire

After the end of the experiment, the children were asked to answer to a list of simple questions, in order to understand

the degree of appreciation for the experiment. Most of the answers were associated to a three points scale.

ANALYSIS OF RESULTS

The aim of the first task (phase 2) was to test the manipulation styles of children and their level of comprehension of the association between the manipulation of a specific object and the related digital function. The best results were achieved with the plate (100% of children understood the association). Optimum levels of performance were obtained with the cube and the cylinder (respectively, 90% and 85% of children understood the association). As expected, the barrel was the most difficult object (20% of children fully understood the association with the digital functions), because of its composite morphological nature and the higher number of functionalities associated to it. The experiment revealed also manipulations styles different from those ones that in this test were considered relevant for the association to functions, but that were perfectly legitimated by the object affordance. For example, some children rotated the cylinder so that they could see one of the planar faces. Other children tried to orient the barrel in the direction of the screen or tried to shake it. The most difficult thing to understand was the need of maintaining the main rotational axis of the barrel in a horizontal position while rolling the artifact.

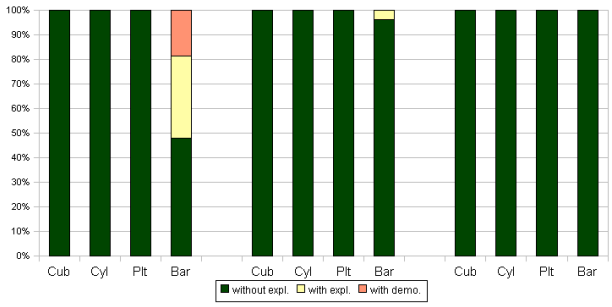

Figure 4. Query and navigation phases – three iterations

Fig. 4 resumes the results obtained for the three iterations of the query and navigation tasks (phase 3), discriminating between tasks resolved by the children without explanation, with verbal explanation by the teacher or with a practical demonstration of object manipulation. The data collected show that the children accomplished three iterations of the query task without any suggestion by the teacher about how to manipulate the objects. The first iteration of the navigation task shows a different but interesting scenario. Nearly 50% of the children succeeded in navigating between the images resulting from the query without any explanation. Only one child required verbal support during the second iteration of the task and all the children were able to finish their work without any help during the third iteration.

Answers from the questionnaires show a general appreciation for the interface by the children. 100% of them declared that they enjoyed playing with the magical objects. Children were then asked to express their opinion about the ease of use of the different objects. The children confirmed that the barrel was the most difficult object to use. In spite of that, a large part of them (i.e., 60% of children) judged this artifact as one of the most interesting objects.

CONCLUSIONS

The results obtained suggest that tangible interfaces may be used for allowing preschool children to query and navigate multimedia information systems. The experiment has evidenced the high learnability of the interface. The design of the mapping between classes of geometric solids and digital variables was particularly successful, because it allowed most of the children to use the query interface without any specific explanation about how to manipulate objects. The interface represents therefore an incremental step towards the universal access to information. At the same time, the interface has shown its potentiality as an educational tool for introducing children to complex tasks such as the composition of a query with different types of variables and the navigation of the query results. We gratefully acknowledge the direction and the teachers of the School “Beato Lorenzino” in Marostica, and in particular Martina Mazzari and Barbara Zanotto, for their support in the successful outcome of the experiment.

REFERENCES

1. Antle, A. N., Droumeva, M., and Ha, D. 2009. Hands on what?: comparing children's mouse-based and tangible-based interaction. In *Proceedings of IDC '09*, 80-88
2. Bruikman, H., van Drunen, A., Huang, H., and Vakili, V. 2009. Lali: exploring a tangible interface for augmented play for preschoolers. In *Proceedings of IDC '09*, 174-177
3. Camarata, K., Do, E. Y., Gross, M. D., and Johnson, B. R. 2002. Navigational blocks: tangible navigation of digital information. In *CHI '02 Extended Abstracts on Human Factors in Computing Systems*, 752-753
4. Detken, K., Martinez, C., and Schrader, A. 2009. The search wall: tangible information searching for children in public libraries. In *Proc. of the 3rd Int. Conference on Tangible and Embedded interaction*, 289-296
5. Gibson, J. J. The Theory of Affordances. In R. E. Shaw & J. Bransford (eds.), Perceiving, Acting, and Knowing. Lawrence Erlbaum Associates, Hillsdale, NJ, 1977
6. Ishii, H. and Ullmer, B. 1997 Tangible bits: towards seamless interfaces between people, bits and atoms. In: *Proceedings of CHI 1997*, 234-241
7. Norman, D. A. The Psychology of Everyday Things. Basic Books, New York, 1988
8. Norman, D. A. 1999. Affordance, conventions, and design. *Interactions* 6, 3, 38-43
9. Terrenghi, L., Kranz, M., Holleis, P., and Schmidt, A. 2006. A cube to learn: a tangible user interface for the design of a learning appliance. *Personal Ubiquitous Comput.* 10, 2-3, 153-158
10. Ullmer B., Ishii H., Jacob R. J. K. Tangible Query Interfaces: physically constrained Tokens for manipulating Database Queries. *Proceedings of INTERACT 2003*
11. Wii.com, http://www.wii.com, checked 20/4/2010
12. WiiuseJ, Java API for Wiimotes, http://code.google.com/p/wiiusej/, checked 20/4/2010