TeddIR: Tangible Information Retrieval for Children

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ABSTRACT
Despite several efforts to make search engines more child-friendly, children still have trouble using systems that require keyboard input. We present TeddIR: a system using a tangible interface that allows children to search for books by placing tangible figurines and books they like/dislike in a green/red box, causing relevant results to be shown on a display. This way, issues with spelling and query formulation are avoided. A fully functional prototype was built and evaluated with children aged 6–8 at a primary school. The children understood TeddIR to a large extent and enjoyed the playful interaction.

Categories and Subject Descriptors
H.3.3 Information Storage and Retrieval: Information Search and Retrieval; H.5.2 Information Interfaces and Presentation: User Interfaces

General Terms
Human Factors

Keywords
Tangible User Interfaces, Children, Information Retrieval

INTRODUCTION
While the ability to successfully retrieve information from digital sources such as catalogs, databases and the web is becoming increasingly important, this is still a difficult task for children. Because of their limited experience and cognitive abilities, they tend to have difficulties using conventional catalogs and search engines [2]. Problems occur especially with information retrieval systems based on textual keywords, where children were found to have difficulties with finding search terms and spelling [8]. Additionally, children use unsupported techniques – such as querying by natural language – due to a lack of understanding of the underlying system [2]. A recent study among children of ages 7, 9, and 11 by Druin et al. [3] confirms that these problems persist. This is despite the fact that children grow up as 'digital natives' and that search engines – like Google – offer assistance through suggestions of keywords and spelling corrections. As suggested in the study by Druin et al., a solution might be found in alternative input methods.

Figure 1. The prototype in the set-up used during evaluation.

One such alternative is the tangible user interface (TUI). By replacing keyboard input with an interface based on tangible objects, or *tangibles* for short, issues with spelling and query formulation are avoided. In an effort to understand how TUI's can contribute to making search tasks such as information retrieval (IR) easier, we have built and evaluated TeddIR. TeddIR is a system that allows children to access a library catalog using a TUI. In TeddIR, keywords are replaced by their tangible equivalents. A fully functional prototype was designed and evaluated at a primary school. The evaluation focused on children's ability to perform IR tasks using a TUI as well as their experience.

TEDDIR DESIGN
TeddIR is a system with a tangible interface for children who are looking for books to read. The intended age group is 6–8 years, but we have informally observed that older children and even grown-ups are also attracted to TeddIR. The design, shown in Figure 1, consists of two boxes, a display and a set of tangibles. One box is green and shows a happy smiley, the other box is red and shows a sad smiley. The children search by placing one or more tangibles in one or both

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boxes. Placing a tangible in the green box means: look for books that match the tangible. Placing a tangible in the red box means: avoid books that match the tangible. Tangibles can be inserted or removed at any time.

There are two kinds of tangibles: *figurines* and *books*. Figurines, shown in Figure 2, represent concepts. Some of these are abstract, some concrete. A dog, for example, stands for books about dogs, whereas a spider stands for books with scary subjects in general. We have made 20 such tangibles, representing familiar concepts such as 'family', 'cats', 'horses', 'cars', and 'love'. Books stand for similar books. Children can pick a book they have read and like, and put it in the green box. Books they dislike can be put in the red box.

Inserting or removing a tangible from a box has an immediate effect on the display that is placed between the boxes and shows the results and the contents of the boxes. The largest part of the screen, shown in Figure 3, is used to show the covers of the twelve most relevant books. In the bottom corners, two panes depict which tangibles are currently in the green and red box. To indicate that an action in the physical world triggers reactions in the virtual world on the display, all display updates are visualised using animated transitions. Interaction with TeddIR is a continuous flow without predefined endpoint. Children can play with it until they are bored or have found what they are looking for.

Technically, the tangibles are equipped with ISO 15693 'vicinity' RFID tags of the same kind Dutch libraries put in their books. The green and red boxes are each equipped with an RFID reader that is hidden from sight.

Figure 2. Some tangible figurines

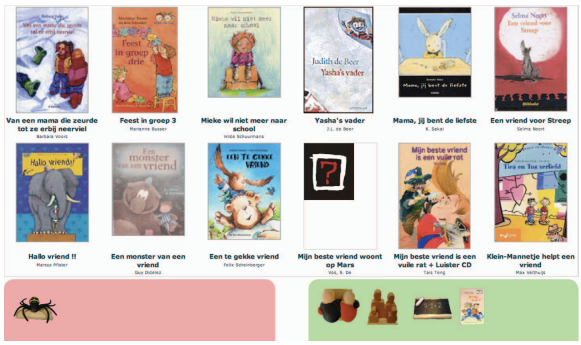

Figure 3. Screenshot of the GUI

The books that can be sought are collected in a database that, besides bibliographic information, holds a picture of the cover, a set of keywords, and a description of the book. Books are shown on the display in the order of decreasing relevance. The relevance is calculated using a combination of similarity search and Euclidean distance, where each tangible in the green and red boxes has respectively a positive or a negative effect on the relevance ranking.

The motivation for this design is as follows. The reasons for moving away from an interface that has the child type in keywords have already been given in the Introduction. Children have trouble scrolling [2] and using multi-page displays [3]. Therefore, only the top twelve results are shown on a single page; scrolling is not possible. The design relies on the ability of children to transfer information from the real to virtual world and vice versa, as also noted by Göttel [5]. Finally, TeddIR is playful. Children can play by inserting and removing tangibles just to see what happens.

EVALUATION

To assess the usability of the prototype, and test how well children understand the concept of using a tangible interface for browsing and searching a collection of books, an experiment was conducted at a Dutch primary school. The goal of the evaluation was to gain insight into how children use such a novel interface, rather than prove its effectiveness. Therefore an explorative, qualitative approach was chosen. Children have trouble dealing with incomplete systems because they find it hard to mentally complete missing steps in the interaction [1]. Therefore the evaluation was performed with a fully functional prototype.

Participants

Seventeen children participated in the experiment, all third or fourth grade pupils of the same mixed class in a Dutch primary school. Of the seventeen participants, six (35%) were boys and eleven (65%) were girls, all between 6 and 8 years old. All but one had been to a library before and they generally had used a computer at home or elsewhere.

Methodology

In determining the experiment design, special care was taken to take into account the children's developing cognitive abilities, such as the capability to concentrate or to verbalise their thoughts, but also the ease with which they adjust to strange environments and surroundings [9, 11]. Moreover, since the goal was to explore the usability of a relatively new type of interaction for information retrieval, it was especially important to gather as much information as possible from the children interacting with the prototype. It has also been found that it is very difficult to obtain useful results from post-hoc surveys and that the most valuable information comes from children verbalising while interacting [10, 11]. Also, methods that have systematic procedures for prompting children to provide verbal information seem best at eliciting verbal comments [11]. Therefore, the method of Co-Discovery, chosen to make participants more at ease, was combined with that of Active Intervention, where the evaluator prompts children to answer questions while they interact with the system under evaluation [11].

Demographic information about the children and their experience with computers and libraries were gathered during a pre-experimental unstructured interview. Also, children were asked some questions to determine their understanding of how the system worked at the end of the test. The tests were captured on video and all interactions with the prototype were logged.

Test procedure & set-up

All test sessions took place on the same day, in an empty classroom of a Dutch primary school, with the set-up as in Figure 1. Special care was taken to adjust the test procedure and set-up to children, using the guidelines by Hanna et al. [6]. The whole session was recorded with a video camera, which was placed behind the children, away from the prototype, so it would not distract them [6].

During a plenary session, the two testers were introduced to the children by their teacher. For each of the eight sessions, a group of two or three children was taken from the classroom. Each session began with an informal conversation meant to put the participants at ease. This conversation doubled as a briefing and an informal interview about their age and their experience using computers and libraries. Next, the participants were given some time to play freely with the system.

After this, the children were asked to perform two goal-directed tasks: *(1) Find books about soccer*, *(2) Find books about dogs, but not about soccer*. As suggested by Hanna et al., children were encouraged to perform the tasks by having an evaluator pretend to need help doing something [6]: (*"I want to read a book about soccer, can you show me books about soccer on the screen?"*). If necessary, they were broken into smaller pieces (*"do you see anything on the table that could help me find books about soccer?"*).

The sessions were ended with some questions to determine how the participants experienced searching with the system and how well they understood how it worked. Depending on how the session had gone, a selection of the following questions was asked, in the form of an unstructured interview:

- Did you have fun, or was it boring?
- Do you think it is childish?
- Was it difficult or easy?
- What should one do to find books about soccer?
- What happens if you put a soccer ball in the green box?
- What if you want books about dogs but not about soccer?

RESULTS & DISCUSSION

The children evaluating the prototype all had a lot of fun in doing so. They not only reported this during the closing interview, stating that it "is like a game", but were seen to continue playing with the system or the tangibles after the tasks were completed. All participants understood the relation between the physical boxes and the coloured boxes on the screen. When asked, they could explain their behaviour, and they often repeatedly inserted and removed tangibles into the boxes while looking at the screen to watch the animation of them appearing and disappearing.

The children understood the meanings of the tangibles, even with more abstract tangibles: the 'spider' figurine, for example, represented not only spiders but also other scary things. Participants took this abstraction for granted or deduced it from the dynamic results and had no trouble mixing the abstract and the concrete. This was apparent from the remarks while playing and during the closing interview.

Participants were able to successfully complete task (1) in six out of eight sessions. Also, they were able to explain how to accomplish the task afterwards during the interview. Task (2) required both that the boxes be emptied to start a new search, as well as the use of the 'negative' box and therefore posed a bigger challenge. Task (2) was completed in only four out of eight sessions. Only a few children were observed to properly use the red box and even fewer were able to explain its function. The few groups that completed both tasks in the allotted time were presented with an additional task: search using a book as tangible. The results of these tests were inconclusive.

Although the results were presented using a picture of the book's cover, along with its title and author, participants only looked at the pictures. This is in line with most children reporting during the interviews that they currently choose their library books mostly by looking at their covers, rather than by reading the description. There were multiple occasions where a participant would attempt to touch the screen in order to interact with the system. For example, they wanted to "know more about this book" and therefore used the result as if it were presented on a touch screen.

RELATED WORK

Previous efforts like Yahooligans [2] have tried to make IR systems more suitable for children, by adjusting an existing GUI. These solutions often go unnoticed because children do not look at the display while they type [3].

Systems that attempt to provide alternate input methods include StorySurfer [4], which allows children to browse a library catalog by stepping on buttons and dragging a cursor across a projected floor surface. Children enjoyed the system's full-body interaction style, however they tended to decode it as a large scale desktop computer.

Other systems that more closely resemble our interaction style of using a TUI for input with a GUI for output include Panze [7], Ely the Explorer [1], ProBoNO II [5] and the Roman dining room puzzle by Xu et al. [12]. In ProBoNO, one uses a tangible 'game piece' on a play board to navigate an on-screen maze. This 'prop-based input' uses a single tangible for controlling the position in a virtual world. In the approach chosen for Panze, Ely the Explorer and the Roman dining room puzzle, every tangible represents information. In the Roman puzzle for example, every tangible maps to a page of information about that object. In TeddIR every tangible stands for an abstract concept, which is fundamentally different. The approach used in TeddIR also differs from these systems with respect to its purpose; rather dan for entertainment or education, it is designed to help children with IR. To our knowledge, this has not been tried before.

CONCLUSIONS AND FUTURE WORK

In an effort to make an easier information retrieval system for children, we have built and evaluated TeddIR. TeddIR uses a tangible interface, consisting of a red box and a green box, to allow children to search for books to read. Instead of typing in keywords, children search by putting tangible figurines or books in the boxes to indicate that they like or dislike them. A display, used to present the results, reacts immediately on placement or removal of tangibles from the boxes and all interaction is continuous, without predefined endpoint. As we expected, children enjoyed playing with TeddIR. The sometimes abstract meaning of the figurines was grasped by all children and almost all of them could use them to perform simple search tasks. The interaction with TeddIR does not suffer from spelling errors and children are not required to know the right words to search.

On the other hand, the meaning of the red box was not apparent for most children when using figurines. This is not surprising considering earlier reports of users having problems with the NOT operator in search [8]. We do not know how children would fare with books instead of figurines because we have not been able to test this.

On a number of occasions during our test, children wanted to operate the display as if it were a touchscreen. This suggests they understood this kind of interaction and expected it to be supported. Replacing the current passive display by a touchscreen and testing the system in a more realistic environment such as a library is left for future work, as is more extensive experimentation with books for tangibles.

The system has limitations. First, it relies on the availability of a database with rich information about the books that can be searched. Second, there are limitations to the use of tangibles. This is obvious for figurines. Too few figurines means most books cannot be found. Too many figurines shifts the problem from finding a book among a pile of books to finding a figurine among a pile of figurines. These limitations will place constraints on the nature and the size of the book collection that can be searched this way. These constraints will have to be elucidated by future research. Similar objections will apply to books for tangibles, except when the child has recently read the books in question. A child will be able to distinguish between a book she likes (green box) and a book she dislikes (red box). We can imagine a library that equips the spot where books are returned with a green and a red box. The child that uses these boxes immediately gets an advice for further reading. Even adult library users may benefit from this service.

Our results indicate that for children, tangible interfaces constitute a promising alternative to keyboards as input device for a search task. Of wider significance is our finding, that children do not have trouble with figurines that stand for abstract concepts. It shows that even though children of the age group investigated by us have difficulties verbalising abstractions, they understand abstractions to the extent that they can work with them. This significantly increases the potential application area of tangible interfaces for children.

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