AR in the Library: A Pilot Study of Multi-Target Acquisition Usability

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Abstract

Libraries use call numbers to organize their books and enable patrons to locate them. To keep the books in order, library workers conduct a time-consuming and tedious task called "shelf-reading." Workers look at the call numbers on the spines of each book in the library, one at a time, to make sure they are in the correct places.

ShelvAR is an augmented reality shelf-reading system for smart phones that reduces time spent, increases accuracy, and produces an inventory of the books on their shelves as a byproduct.

Shelf-reading requires rapid acquisition of many targets (books). Unlike many target acquisition tasks considered in the AR literature, the user is not trying to select a single target from among many. Instead, the user is trying to scan all of the targets, and must be able to easily double-check that none were missed. Our goal is to explore the usability of augmented reality applications for this type of "multiple target acquisition" task.

We present the results of a pilot study on the effectiveness of ShelvAR. We demonstrate that individuals with no library experience are just as fast and accurate, when using ShelvAR, as experienced library workers at the shelf-reading task.

1 Introduction

Shelf reading in a library is a sorting task, but with keys that follow fairly complicated context-dependent rules. In order for library workers to check that books are in the right order, they must look at one book at a time, and it is easy to make mistakes.

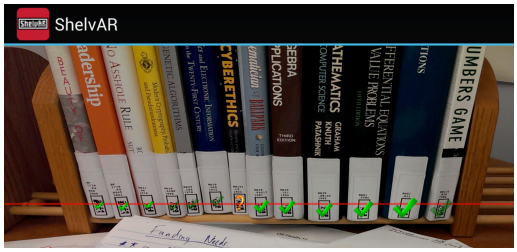

Figure 1: The ShelvAR app interface

Our solution involves adding a 3/8" wide tag to the spine of each book. These tags encode the book's call number using a Huffman code designed for the task, enabling the system to work without Internet access.

When we originally posted a video of our prototype to YouTube and Reddit, we received a great deal of interest from librarians, but also some skepticism. Several commenters expressed doubts about whether a system like this could actually be faster than an experienced library worker.

The main purpose of this poster is to address this skepticism. Are ShelvAR users really as fast, or faster, than experienced library workers? Are they really more accurate? What types of library workers actually perform better *without* the app?

The ShelvAR app reads the tags on a row of books, and uses simple 2-D augmentations to provide information to the user. If the books are in the correct order, all book spines are marked with a green check-mark. If books are out of order, the ShelvAR app calculates the most efficient way to rearrange the books, and marks those that need to be re-shelved with an orange question mark.

2 Related Work

ShelvAR solves a multiple target acquisition task while utilizing an AR "magic lens" on a smart-phone. In our case, book tags are targets, and the goal is to acquire (scan) as many of them as possible, as quickly as possible.

Several studies have examined various kinds of AR target acquisition tasks. The CHI and UI communities have produced several projects such as MAGIC, bubble cursors, and Look & Touch [7, 6, 4]. AR researchers have compared the usability of device-perspective magic lenses versus user-perspective views [3, 1] for target selection. However, most of these works involve selection of a single target, as opposed to multiple target acquisition.

There are a number of non-AR approaches to the shelf-reading problem. The ShelfLister app, for example, provides a list of books in the order they ought to be on the shelf, and the user walks down the row, checking off books on the list that are on the shelf. 3M manufactures a product called the "Digital Library Assistant," that does the same thing, but using RFID. Both of these examples, while helpful, still require books to be considered one at a time, rather than in large batches as multiple targets.

For inventory control, some libraries utilize specialized equipment, such as RFID tags or robotic automation. However, for the majority of libraries, such equipment is cost-prohibitive.

There have also been some applications of AR to libraries. Chen et al.[2] provide information about a book on a shelf by snapping a picture of the book's spine. Unlike our system, their system requires an online database of pictures of book spines. As a result, their recognition algorithm takes about 1 second; ours can handle more than a dozen books at a time, at 15 fps.

Like us, Umlauf et al.[5] used fiducial markers for their application. Their project was much broader in scope than ours, supporting navigation as well as annotating multiple books at a time. Unfortunately, they were significantly hampered by the low camera resolutions available to them (320x240).

3 Experiment Design

For this small pilot study we recruited 13 participants. Each participant completed a short 3-question survey, and then performed the shelf-reading task twice, on two different sets of library shelves. Each shelf-reading task involved 6 shelves of books, each shelf 36" wide. Participants did the task once using ShelvAR, and once without it. Whether the participant used ShelvAR first, or did the task manually first, was randomly selected.

3.1 Participant Profile

Our main goal was to evaluate whether or not ShelvAR improved speed and accuracy in shelf-reading. We wanted to know this for two main populations: Undergraduate students that had never

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Table 1: Summary of statistical results

Hypothesis	n_1 and n_2	U	Significance
Inexperienced shelf-readers faster with ShelvAR	7	49	Yes, $P < 0.001$
Inexperienced shelf-readers more accurate with ShelvAR	7	42	Yes, $P < 0.05$
Experienced shelf-readers faster with ShelvAR	6	19	No
Experienced shelf-readers more accurate with ShelvAR	6	18.5	No

worked in the library (these are the types of individuals most likely to be hired to shelf-read in an academic library) and experienced library workers (those individuals most likely to be overseeing the shelf-reading process, and checking results).

Participants self-identified their level of experience with LC call numbers, and with smartphones. This gave us four categories of research subjects, and we had at least 2 of each type of individual among our 13 participants.

3.2 The Task

The shelf-reading task took place in a real working library with a real collection, not in a laboratory setting. We prepared two stacks of books (a stack being 6 shelves) with ShelvAR tags.

In order to test accuracy, we intentionally inserted some errors into the stack before the participant arrived. The experimenter followed randomly generated instructions, such as "Move book 10 to position 3," to add errors to the stack. We intentionally only tested the "low error" condition here, with only a few books out of place. This is by far the more common case in the library. (If a section is completely scrambled, the library worker should just re-do the whole section manually, without ShelvAR.)

The participant, on arrival, completed the survey, and then shelf-read the books, correcting any errors. This task was repeated twice, once using ShelvAR, and once manually.

After the participant left, the experimenter counted the number of un-corrected errors. In some cases the subject actually introduced new errors.

4 Results

This was a pilot study, meant to quickly validate our work so far before we go on to further development. As such the questions we explored were fairly basic, and our focus was on performance (rather than on user acceptance). We expected ShelvAR to significantly improve the performance of inexperienced individuals. We expected that experienced shelf-readers would benefit some from using the system, but less than inexperienced users.

From almost any measure we could think of, the data seems to support these conclusions. For example, we calculated the "speedup", (manual time)/(ShelvAR time). For the inexperienced group we found an average speedup of 2.11, and 1.04 for the experienced group.

We also looked at the percentage of errors corrected. We use (pct corrected using ShelvAR)/(pct corrected manually) as a measure of increased performance. By this measure, the experienced users averaged 0.97 (essentially no change in accuracy), while inexperienced users averaged 1.40 (a 40% increase in accuracy).

The results for inexperienced users are also statistically significant. We used the Mann-Whitney-Wilcoxon rank-sum test to check our hypotheses. For each group of participants we ranked their scores, and compared the rank-sum of the "using ShelvAR" scores with the "manual" scores. Key results are presented in the Table.

4.1 Other Observations

The true value of this pilot study was in showing important design considerations that had been ignored to this point in the project.

One experimental subject had trouble holding the camera up and steady for the extended period of time (5-15 minutes) needed to complete the task. We need to design some disability accommodations to work with the system.

Another experimental subject seemed to have difficulty lining the camera up with the tags to scan them. We suspect that this participant lacked experience with device-perspective magic lens applications (e.g. the preview window of a digital camera).

5 Limitations (and Strengths)

Though not threatening the validity of our main results, the pilot study helped us find some missteps in our experiment design.

Both of the users mentioned in the "Other Observations" section were in the "experienced shelf-readers" group and the "inexperienced smart-phone users" group. Because we didn't have any such users in the "inexperienced shelf-readers" group, this may have biased our results, making them look stronger than they should.

The biggest limitation of this study is that there do not, yet, exist any experienced ShelvAR users. We would like to compare the performance of experienced ShelvAR users with experienced shelf-readers working manually.

6 Conclusions

Our results lead us to believe that ShelvAR will indeed be a useful system for libraries, and an appropriate approach to the problem of multiple target acquisition. The speed and accuracy results we saw indicate that the costs of adopting the system will quickly be recouped in increased productivity and quality of service.

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