

# Page Detection Using Embedded Tags

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## ABSTRACT

We describe a robust working prototype of a system for accurate page-ID detection from bound paper books. Our method uses a new RFID technology to recognize book page location. A thin flexible transponder tag with a unique ID is embedded in the paper of each page, and a tag reader is affixed to the binding of the back of the book. As the pages turn, the tag reader notices which tags are within its read range and which have moved out of its range (which is about four inches). The human interacts with the book naturally, and is not required to perform any actions for page detection that are not usual in book interaction. The page-detection data can be used to enhance the experience of the book, or to enable the book as a controller for another system. One such system, an interactive museum exhibit, is briefly described.

## Keywords

Page ID, page detection, RFID, embedded tags, simultaneous ID, smart documents, electronic books.

## INTRODUCTION

An enormous amount of research, both commercial and academic, has focused on electronic books of one sort or another. However these projects generally present an electronic book as a device with a computer screen. The electronic book is almost never conceived as a real book, with paper pages. This is partly because there was no simple, accurate way to identify what page the reader is on. Though many systems have been attempted, none are in common use.

Systems that gather accurate page-ID data from paper-based books have generally involved either mechanical switch-based systems that are prone to false reads or optical systems that have particular lighting or visual requirements.

Camera-based page recognition systems require particular geometries, uninterrupted line-of-sight and special lighting conditions. Other page-ID systems require the reader to perform a specific act, such as press a button, run a pen over a barcode, or pass the page through a reader. However these solutions are not transparent; they interfere with a person's natural interaction with the book.

For example, Stifelman showed a paper-based electronic notebook that allowed the user to take notes on real paper [3]. Those notes could be cross-indexed electronically because the page-ID was known; but the user had to make sure the edge of the page fit into an optical reader along the side of the notebook. Although it was an elegant solution, it was not completely transparent to the user.

## System design

Our method of page-ID uses the TagIt TIRIS system from Texas Instruments, with simultaneous ID (which allows detection of multiple IDs at one time). A thin flexible transponder tag with a unique ID is embedded in the paper of each page, and a special tag-reader is affixed to the binding of the back of the book.

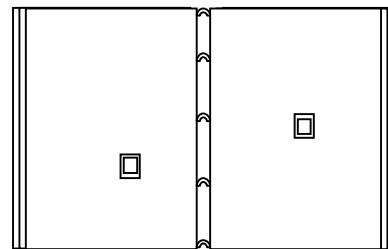


Fig. 1. RFID transponders (tags). Tags are tiny chips with printed copper coils affixed onto clear flexible plastic. These tags are embedded between two sheets of paper that are glued together to make a book page. Each transponder has a unique ID. Geometry in tag layout is of some account; in this system, two tags may overlap by 80% or more, but not completely.

As the pages turn, the tag-reader notices which tags are within its read range and which have moved out of its range (which is about four inches). The human interacts

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with the book naturally, and is not required to perform any actions that are not usual in book interaction.

The TagIt reader communicates with the host computer using a serial protocol. Our code (written in Director Lingo, using a custom “xtra” to handle the serial I/O) sets the tag-reader so that it continually checks for a list of tags within its reading range. This list is received by the computer (WinNT 4.0) and updated as frequently as possible (approximately once a second). As a page is turned, the embedded tag leaves the reading range of the tag-reader, and its absence is noticed. The system can read up to 100 tags in each sweep according to its manufacturer; in practice we have found that using up to 30 tags produces reliable results.

We use the page-ID information to provide appropriate contextual information associated with that page in the book. Some of the dynamic contexts we’ve considered are music, sound effects, voice, specific point lighting, ambient room lighting, moving graphics on a computer screen, and scrolling text. The particular instance we have built provides a running ambient soundtrack for each page in a children’s book. When a page is turned, the sounds associated with the first page fade down in volume while the sounds associated with the new page fade up in volume.

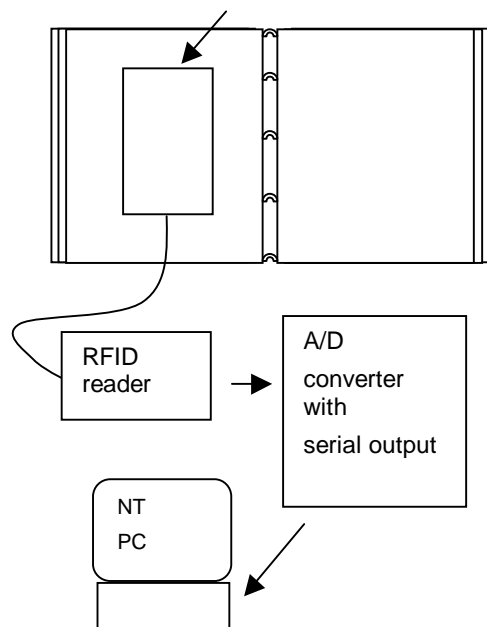


Fig. 2. The RFID antenna is built onto the binding behind right-hand page. As the page is turned, its transponder moves out of the read range of the antenna; the software notices and switches priority to the next page underneath it.

## Other tag systems

The Motorola Bistatix tag-based ID system is another example of a thin, flexible tag system that could be used to determine pageturning in realtime. Unlike the Texas Instruments RFID system, the Bistatix is a capacitive field sensing tag, each having its own rewritable ID. This system, though still in development, is perhaps even more useful for our application since it could conceivably be printed directly onto a paper page, rather than having to be embedded between two sheets like the TagIt. Paradiso’s swept-frequency tags are another interesting tag technology that could be used in this fashion [2].

## Demo application: Listen Reader

The *Listen Reader* is an interactive children’s storybook featuring a rich, evocative ambient soundtrack. We use embedded RFID tags to sense what page the reader is on, and we use capacitive field sensors to measure human proximity to the pages [1]. Proximity measurements control volume and other expressive parameters of the sounds associated with each page. In this instance, the page-ID data controls which set of sounds is presently being heard. Three *Listen Readers* are part of a Xerox PARC installation at the Tech Museum of Innovation in San Jose, CA, which runs March 1 to September 7, 2000. More than 350,000 visitors are expected during this time.

## Conclusion and future work

We envision a version of this technology that is wireless, with the battery power built into the book binding and a wireless serial data link transmitting to a local area network. While we are currently showing it in the form of story books, we envision books of all kinds extended and enhanced in this fashion. For example, a contractor’s book of blueprints could control a computer projection or a 3D set of blueprints – by turning to a particular page in a notebook, the contractor could access appropriate and up-to-the-minute drawings, cost estimates, or design samples.

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