ABSTRACT
Digitalization of documents has become an important technology. The technical challenge is to realize an easy-to-use, simple, and high-speed scanning system. The key point is how the system can decrease the user’s workload when scanning document information on many pages. Our Book Flipping Scanning is a new method of scanning large stacks of paper while the user performs a continuous page flipping action. Here we report the core of this proposed technology, which is simultaneous sensing of 3D paper deformation and the information printed on the pages. Our prototype also has a novel function of reconstructing the document image from a distorted one based on a paper deformation model.

ACM Classification: H5.2 [Information interfaces and presentation]: User Interfaces. - Input devices and strategies.

General terms: Design, Human Factors, Measurement

Keywords: Digitalization, Book Scanning.

INTRODUCTION
The task of converting paper documents into digital data is becoming increasingly important with the progress of highly functional information terminals. Such documents cover any kind of printed matter containing various types of information, ranging from published materials to private memos. The merits of this task include conservation, space saving, ensuring high portability, and facilitating high-speed information searching.

The digitalization of documents requires a scanner to read the stack of papers. Normally, flatbed scanners have been widely used. However, they require the user to scan page-by-page, and it is difficult to achieve continuously flowing scanning for large stacks. This design is considered to be the key drawback leading to the time-consuming operation.

Recently, although some related studies have attempted to scan books by using a camera [1], they do not focus on the workload involved in multi-page scanning. On the other hand, the digitalization of library books has been aggressively pursued by some organizations, like Google [2]. The system employed is a dedicated one equipped with an automatic page-flipping mechanism, which significantly reduces the burden placed on the user. However, the problems of large size and high costs remain for personal use.

In this study, we target a high-speed scanning technology with a simple interface. We consider that the breakthrough is in the design of the method of reading multiple pages. Our proposed approach is based on a novel scanning technique that reads pages continuously while the user rapidly flips the pages. We call this scanning method Book Flipping Scanning. A conceptual image showing how this technology might work is shown in Figure 1. The technological challenges are described in the next section.

BOOK FLIPPING SCANNING

As shown in Figure 1, our system performs scanning while pages are being flipped. This allows the digitalization of large stacks of papers to be drastically simplified. Also this type of system is promising because of its ability to be implemented with a very simple configuration. Therefore, Book Flipping Scanning will enable easy and high-speed scanning and realize various useful applications, such as allowing users to carry around books to be scanned quickly at any time, and searching for specific keywords from personal books and memos.

The key technology to realize Book Flipping Scanning is a novel camera system. The target pages to be scanned are assumed to be highly deformed. Therefore, two kinds of information must be obtained by the camera: marks on the paper (page images), including figures and characters serving as document information, and 3D deformation information. This obtained deformation will allow distorted documents to be corrected, thus recovering the original page images. Also, the deformation of pages is assumed to be constantly changing at high speed. The prototype described in the next section is designed to resolve these issues.

PROTOTYPE
We constructed a prototype, illustrated schematically in Figure 2. Our developed system obtained the paper deformation...
by using a so-called active stereo method. For this method, the scanning-based principle has been mainly used for still objects. However, in our application, the target constantly moves, and thus, a one-shot 3D sensing system capable of operating at high frame rates is strongly desired [3]. The developed prototype employed a laser line projector (16 lines) and a high-speed camera (1280 × 1024 pixels, 500 fps).

Also, high-frame-rate imaging allows us to obtain both the paper deformation and the marks on it with only a single camera. This was achieved by switching between two kinds of projected light alternately for every captured frame: a projected pattern for the active stereo method and normal light for page image acquisition.

In addition, our prototype reconstructed the original flat page image from the acquired distorted image. This was realized by using the distinctive features of paper as a developable surface to construct a model. This model describes in detail how a paper-like non-rigid surface deforms, even when the observed 3D information is low-resolution data.

RESULTS

In the experiment, we used a B6-sized comic book as the target surface. The experimental environment is shown in Figure 3, which shows the page images and the laser pattern images captured alternately. Figure 4 shows mapping of the page images onto the obtained 3D structure. deformed three-dimensionally. The captured page image and the reconstructed flat image are shown in Figure 5.

CONCLUSION

We have proposed a new method of scanning books with a single camera. The critical task is reducing the workload involved in multi-page scanning. The proposed Book Flipping Scanning overcomes this problem by reading pages continuously while a user rapidly flips the pages.

We tested the method with a comic book and reconstructed flat images. The method shows great promise for its noise robustness and generality in solving the problem of paper deformation during scanning.

One of the next challenges is to realize a more simple configuration, which we envision being implemented on mobile platforms such as cell phones, as shown in Figure 1. We plan to develop a system that obtains complete information by using only a single camera, without a separate pattern projector. Moreover, a single page is observed several times thanks to the high frame rate of the imaging system. Integrating the multiple datasets obtained could help to improve the quality of detail of the reconstructed final image.

REFERENCES