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1954 - 2004 50 Advancing Control Technology CSS IEEE

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Fast Ferry

Automated Book Scanning

A Real Page Turner

With the advent of digital technology, it has become possible to access a huge body of documents from virtually any location. Unfortunately, the world's libraries are filled with books and other bound documents that are not available except through direct physical access to the material. Consequently, much of the wisdom and knowledge of the past remains underutilized. Worse, there is a possibility that many older documents will be discarded due to the cost of storage and maintenance, a potentially tragic loss to our civilization.

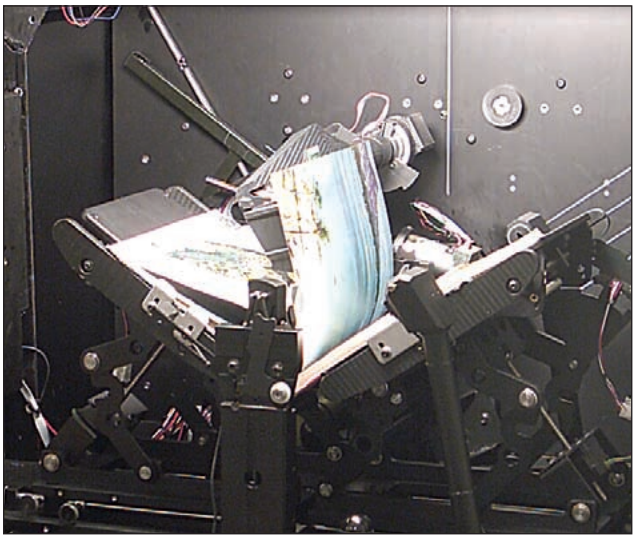
Although paper documents can be preserved by imaging and digitization, manual book scanning is expensive and tedious. Consequently, lesser-used documents tend to have a lower scanning priority. Yet future generations of scholars will undoubtedly find that many of the lost documents would have been crucial to their research.

The Kirtas APT BookScan 1200. This fully automated device scans and digitizes books at a rate of 1,200 pages per hour. With a 564-year backlog of books amounting to well over 1 trillion pages, as well as an untold number of corporate records and government documents, this machine can contribute to the worldwide preservation of human knowledge and culture.

To address this problem, Kirtas Technologies of Victor, New York, offers the APT BookScan 1200, an innovative machine that can scan books with automated page turning at a rate of 1,200 pages per hour. The developer of this machine is Lotfi Belkhir, president of Kirtas Technologies. *IEEE Control Systems Magazine* (*CSM*) spoke to Dr. Belkhir to understand how Kirtas applies control technology to the APT BookScan 1200.

CSM: *Let's start with the need for automated technology. Do you have an estimate of how many pages in libraries as well as government and business archives, in the United States and worldwide, can benefit from automated scanning?*

Belkhir: The numbers are astounding and reflect a 564-year backlog of documents, beginning with the advent of movable type in 1440. Surveys conducted by the American Library Association estimate the number of unduplicated titles worldwide at about 3.2 billion books. At an average of 300 pages per book, this figure represents approximately 1 trillion pages. This number, however, doesn't include corporate records or government documentation, such as state vital records, property deeds, and other bound documents that fall outside the scope of these surveys.



Page-handling technology developed for the Kirtas APT BookScan 1200. The V-shaped SmartCradle uses independently moving plates to precisely maintain the top pages of the book in the focal plane of the camera, while the Sure-Turn robotic arm uses a vacuum pickup head, edge-detection sensors, and puffs of air to reliably turn pages whose texture ranges from onion skin paper to photographic stock.

CSM: *Can you please tell me a little about your background, as well as the background of the engineers who developed the APT BookScan 1200?*

Belkhir: I am a physicist by training. I hold a Ph.D. in physics and an M.B.A. in management of technology. I left academia to join Xerox as a research scientist in 1995. While at Xerox, I held several management positions in R&D, product development, corporate strategy, and planning, as well as new business development. Kirtas' chief engineer, Tuck Taylor, is a recognized leader in the field of media and paper handling. He's the inventor of the first automatic document handler that helped Xerox leapfrog the competition in the 1980s. He also holds over 30 U.S. patents in paper handling and inkjet technology. Our lead technologist is Mike Walker, who developed our controls and firmware strategy. He was the architect for the firmware and controls subsystems of several successful Xerox products as well.

CSM: *As a control engineer, I would find the task of designing a machine that can turn 1,200 pages per hour for books of any size and any paper texture a daunting task. Can you please describe some of the innovations that are brought to bear to achieve this capability?*

Belkhir: Indeed the control strategy and implementation has been a major challenge. In our desire to offer a high level of reliability and flexibility, we quickly found ourselves pushing the limits of modern control engineering.

As you know, the heart of the BookScan 1200 is the automatic page turner, which includes the SureTurn™ page-turning arm and the SmartCradle™ V-shaped dynamic cradle.

The SureTurn robotic arm incorporates a vacuum pickup head and accommodates book sizes ranging from $5'' \times 8''$ to $10'' \times 13''$. The arm also can reliably turn pages ranging from onion skin paper to photographic stock without any operator intervention or adjustment. The system uses a sensor that detects the page edge during operation, and automatically maintains the pickup head at a fixed distance from the page edge, to prevent contact of the head with the potentially brittle edges of rare or fragile books. This same sensor is also used to detect page drops, multifeeds, and loose pages, helping to ensure gentle, reliable, and error-free page turning. The controls are designed to manage page-turning speeds that can be continuously adjusted between 20–100% of the rated speed. During operation, the three-dimensional motion of the SureTurn arm is controlled with high precision and is carefully synchronized with the other subsystems to ensure proper operation. A foremost concern for us is to prevent any potential damage to the book pages.

The V-shaped SmartCradle is comprised of two independently moving plates that dynamically and precisely maintain the top pages of the book in the focal plane of the camera. The heights of the left and right pages are continuously monitored by a set of optical sensors. By relying on the cradle, instead of the camera, to physically maintain our focus, we have better control over the timing of imaging, which ensures a crisply focused image for each page. As the book weight shifts from the right plate to the left plate, the cradle slowly rotates underneath the book to adjust to the shifting position of the book spine.

In addition to the SureTurn arm and the SmartCradle subsystems, we also use page fluffers timed to puff air between pages shortly before page pickup, and upper and lower page clamping to ensure page flatness before imaging.

CSM: *How many APT BookScan 1200s are operating today, and where are they located?*

Belkhir: While I can't divulge the identity of our first customers, or the exact number of machines in operation, I can tell you that our first customers have been publishers of electronic databases, as well as providers of online access, print-on-demand, and e-books. We started shipment of the BookScan 1200 in October 2003 and have been shipping new units every month since then.

(Continued on p. 84)

Intelligent Sports Equipment

Head, the manufacturer of a wide range of equipment for skiing, tennis, and other sports, has developed a new line of snowboards based on Intellifibers, which have already been incorporated in their line of Intelligence tennis racquets. Head describes the operation of these snowboards as follows.

How It Works

1) Intellifibers in front of your bindings generate energy from vibrations.
2) This energy is transmitted to a microchip at the center of the board.
3) The chip amplifies the impulses and sends them back to the Intellifibers in the right intervals.
4) The intellifibers stiffen up.

This means within 0.005 seconds (lightspeed!) the intelligence board stabilizes. Depending on your speed and snow conditions, it changes its torsional flex for more grip and control. The harder you ride, the more energy goes into the Intellifibers.

The award is presented at the annual CSS awards ceremonies held at the IEEE Conference on Decision and Control. The deadline for nominations is 14 May 2004. Nominations should be sent to the chair of the Axelby Award Committee, Prof. Abraham Haddad, ECE Dept. (L352), Northwestern University, Evanston, IL 60208-3118 USA; +1 847 491 3641; fax +1 847 491 4455; ahaddad@ece.northwestern.edu.

IEEE Transactions on Control Systems Technology Outstanding Paper Award

This annual award is selected among papers that appeared in *IEEE Transactions on Control Systems Technology* during the previous two years, 2002–2003 (volumes 10 and 11), based on originality, relevance of the application, clarity of exposition, and demonstrated impact on control systems technology. At most one award per year is presented at the annual CSS awards ceremonies held at the IEEE Conference on Decision and Control. The award consists of a plaque (one for each author). The deadline for nominations is 14 May 2004. Nominations should be sent to the chair of the IEEE Transactions on Control Systems Technology Outstanding Paper Award Committee, Prof. Marc Bodson, University of Utah, Electrical and Computer Engineering, 50 S. Central Campus Dr. Rm 3280, Salt Lake City, UT 84112-9206 USA; +1 801 581 8590; fax: +1 801 581 5281; bodson@ece.utah.edu.

When Are Nominations Due?

The deadlines for furture awards are:
IEEE Technical Field Awards—31 January
IEEE Fellow Awards—15 March
CSS Prize Papers—15 May
IEEE Medals—1 July
AACC Awards—1 December

IEEE Control Systems Magazine Outstanding Paper Award

This annual award is selected from articles and columns that appeared in *IEEE Control Systems Magazine* during the previous two years, 2002–2003 (volumes 22 and 23), based on the impact on and benefit to CSS members. At most one award per year is presented at the annual CSS awards ceremonies held at the IEEE Conference on Decision and Control. The award consists of a plaque (one for each author). The deadline for nominations is 14 May 2004. Nominations should be sent to the chair of the CSM Outstanding Paper Award Committee Dr. Tariq Samad, ACS Advanced Technology Lab, Honeywell Laboratories, 3660 Technology Drive, Minneapolis, MN 55418 USA; +1 612 951 7069; fax +1 612 951 7438; tariq.samad@honeywell.com.

Applications of Control

(continued from p. 14)

CSM: *Do you have a personal vision of the impact of Kirtas' technology on the future of our society?*

Belkhir: Our libraries are home to our collective wisdom, yet libraries are expensive to maintain, and documents are lost or simply decay with time. Over the long term the dangers are even greater. In ancient times, the library at Alexandria was destroyed, and, more recently, on 25 August 1992, the National and University Library of Bosnia and Herzegovina was destroyed along with its contents of almost 2 million volumes. These and similar events represent tragic losses of inestimable proportions. Digitized documents can be stored at multiple locations worldwide, assuring their survival for the long term. I believe that the APT BookScan 1200 can contribute to the preservation of our worldwide heritage, for the benefit of all.

Furthermore, our lives are currently profoundly affected by one of the most powerful and global trends of our time: Digitization. All forms of activities, communication, and contents are quickly and massively moving to the digital domain. Unfortunately, when it comes to content, often the least valuable material (to put it kindly) is finding its way to the Internet, while the bulk of human knowledge is being left behind. Unless we quickly and massively move this human legacy from books to bytes, the best of what we have to offer will be, for all intents and purposes, lost to the future generations of our society.

This vision is truly at the very heart of what drove me to launch the Kirtas endeavor.