How Computing Will Change the Face of Retail

Antonio Krüger and Johannes Schöning,
German Research Center for Artificial Intelligence
Patrick Olivier,
Newcastle University

Pervasive computing platforms present a major new opportunity for retailers to lower costs and build a deeper relationship with customers.

Attitudes to shopping are as varied as people themselves. For some it's the ultimate mundane activity borne purely out of necessity. For others, it's an emotional experience, perhaps best articulated by actress and model Bo Derek: "Whoever said money can't buy happiness simply didn't know where to go shopping." For most of us, the reality lies somewhere between these two extremes.

Whatever our perspective, most acts of shopping depend upon a complex infrastructure that is largely invisible to the average consumer. This includes both physical structures (for example, warehouses and distribution centers) and virtual spaces dynamically constructed around us (for example, Web retail stores). It also includes logistical mechanisms that ensure products arrive at a certain place at a certain time coincident with customer needs. Logistics constitutes a significant component of the total costs for retailers and suppliers alike and has long been a driver for technological innovation, from the barcode, which was introduced in the mid-1970s, to the more recent use of item-based RFID tagging.

Other recent innovations have sought to minimize the cost of human resources in retail operations, especially in regions where labor is expensive. For example, customers can use self-service scales and automated cashiers to weigh and pay for goods themselves, while DVD and videogame rental kiosks likewise remove the need for store clerks.

Indeed, retailers have imaginatively deployed IT throughout the infrastructure, from automated sales management to reduce administrative costs to data mining to drive sales. The emergence of pervasive computing platforms presents a major new opportunity to further lower costs as well as build a deeper and more sustained relationship with customers.

ROLE OF THE PHYSICAL MARKETPLACE

Some might argue that, given the seemingly relentless growth of online shopping, there is little need for technological innovation in real-world stores. However, physical marketplaces are here to stay for many reasons, not least of which is the increasing social function that shopping malls and large retail spaces serve in economically developed societies.

In the highly competitive retail food industry, which traditionally has small profit margins, the substantial costs involved in home delivery services are a compelling argument for the continuation of physical supermarkets. Food retailers are still grappling with the high expenses associated with physically selecting and delivering online offerings from a store or warehouse.

In addition, for the foreseeable future, consumers will demand that certain classes of shopping remain real-world activities. For example, it's hard to imagine fresh food shopping, which for most people has a visceral appeal, being replaced by a purely online experience. Retailers' fresh food offerings are extensive: a large food retailer with 100,000 items on

Published by the IEEE Computer Society

sale typically offers, for example, more than 300 different types of fresh cheese. Such diversity of choice is a key element of brand demarcation.

FROM BARCODES TO RFID TAGS

The barcode revolutionized both logistics and in-store payment processing. However, while the barcode imposes almost zero cost to the producer, it has one major disadvantage: barcode readers need a line of sight for successful access. This has severely limited application of the technology in crucial aspects of retail operations, such as inventory management. Likewise, in an age of contactless payment, the ritual of product scanning at check-out seems cumbersome and labor intensive.

RFID tagging of products could overcome these limitations. While RFID tags are already widely used in the supply chain to identify palettes and cartons, only recently have some producers begun using the technology at the item level. For example, German textile manufacturer Gerry Weber introduced RFID tagging of clothes in 2010. The company sews 14-cent RFID tags into clothing items not only to track them throughout the entire logistics process but also to quickly identify out-of-stock and out-of-shelf events. The tags also prevent theft and provide care instructions to end customers.

While RFID tagging of high-value goods is cost-effective, tagging low-value items such as food products currently is not. Nevertheless, item-level tagging could provide a wealth of information about food products—for example, their point of origin, ingredients, and storage history. Companies like Barcoo (www.barcoo.com) provide product provenance services today, but item-level RFID tagging could equip every instance of every product with a digital memory (www.semprom.de/semprom_engl), which would revolutionize business-to-business and business-to-consumer retail processes.

DIGITAL SIGNAGE

Novel in-store services will arise from the replacement of traditional analog displays by digital signage. High-resolution electronic price tags will not only ease price labeling, they will constitute dynamic display environments at shelf level.

Finding products on a shelf is often a major problem for customers: the environment's visual richness and the variety of product placements can make search extremely difficult. Retailers could use digital price tags to communicate personalized information to customers—for example, to highlight relevant products or direct shoppers looking for an item to a different shelf. It's easy to imagine a service that connects a shopping list on a customer's mobile device to items on a shelf and flashes the appropriate prices, thereby providing direct visual hints to the desired products.

Novel in-store services will arise from the replacement of traditional analog displays by digital signage.

Digital signage will support interaction with both consumer and store inventory devices, aiding customers and shop employees alike.

MONITORING SHELF INVENTORY

Different events can negatively impact shelf space and sales. For example, articles can be in a disorderly arrangement, wrongly oriented, or on the wrong shelf.

One of the most common events is a product being out of stock (T.W. Gruen, D.S. Corsten, and S. Bharadwaj, *Retail Out of Stocks: A Worldwide Examination of Extent, Causes, and Consumer Responses,* 2002; http://knowledge.emory.edu/papers/1030.pdf). Research indicates that shoppers can't obtain an item they're seeking in a store—either because it's out of stock or not on the shelf—8.3 percent of the time. Empty shelf space is equivalent to a loss of revenue for retailers. It also erodes customer loyalty and can have a long-term impact on market share, as 31 percent of consumers will go to another store to buy a missing article—and while there will likely purchase other items as well.

To remedy this situation, effective shelf management is necessary. Today this is only partly automated, with employees and vendors often manually replenishing shelves. However, various technologies to monitor stock are available (C.P. Metzger, "High Fidelity Shelf Stock Monitoring–A Framework for Retail Replenishment Optimization," PhD dissertation, ETH Zurich, 2008).

One method is to employ RFID technology (C.Y. Wong and D. McFarlane, "The Impact of Auto-ID on Retail Shelf Replenishment Policies," white paper, Auto-ID Center, Institute for Manufacturing, Univ. of Cambridge, 2004). Several shelf systems with RFID readers are already on the market, but the problem with such systems is that each article must be tagged.

To facilitate shelf monitoring, at the German Research Center for Artificial Intelligence (DFKI), we have developed FibreShelf, a prototype system based on technology originally developed by Daniel Jackson and his colleagues at Newcastle University (D. Jackson, T. Bartindale, and P. Olivier, "FiberBoard: Compact Multi-Touch Display Using Channeled Light," *Proc. 2009 ACM Int'l Conf. Interactive Tabletops and Surfaces,* ACM Press, 2009, pp. 25-28).

Figure 1a shows a schematic overview of the FibreShelf system,

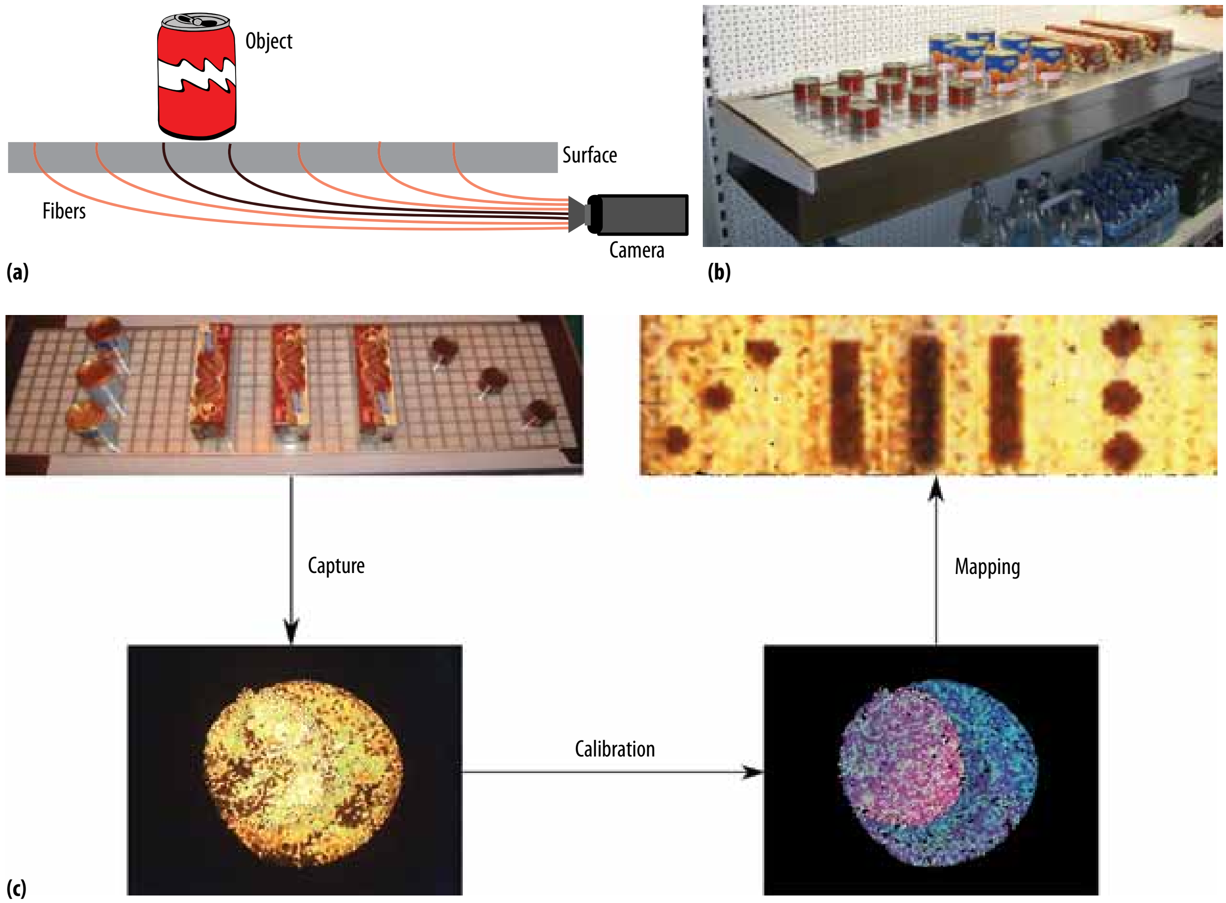

Figure 1. FibreShelf prototype: (a) schematic overview; (b) final prototype integrated in a shelf; (c) raw camera image (left) and reconstructed camera image (right) using a calibration mask.

which consists of a perforated shelf with fiber-optic wires bundled together and interfaced to a camera, and Figure 1b shows the final lab prototype. The camera provides coarse images of objects on the shelf that, with calibration and mapping, can provide information about the objects' position, form, color, motion, and other characteristics. Figure 1c shows raw and reconstructed camera images of a soda can. With further engineering, this technology could be implemented in a shelf board and integrated into a stock inventory system.

AUGMENTED IN-STORE INTERACTION

In addition to check-out aisles, supermarket customers most commonly interact with employee at counters where fresh food such as meat, cheese, and fish are displayed and packaged. These high, wide counters can block the line of sight between customers and service staff, making it unclear to the employee exactly what a customer is pointing to in the display.

To address this problem, we have developed an interactive fresh food counter at DFKI that facilitates communication by tracking customer gestures, thereby increasing customer satisfaction and decreasing service time.

The system uses a Microsoft Kinect camera to recognize the product at which a customer is pointing and displays this information to the employee on a countertop scale, as Figure 2a shows. The scale has two displays: one faces the employee to enable weighing of the product and attaching of price labels, and the second faces the customer to provide ads and other information.

The Kinect's RGB camera provides a depth image capable of tracking the user's arm (A.D. Wilson, "Using a Depth Camera as a Touch Sensor," *Proc. 2010 ACM Int'l Conf. Interactive Tabletops and Surfaces*, ACM Press, 2010, pp. 69-72). Figure 2b shows the scene in Figure 2a as captured by the camera and the depth view. The system uses the Freenect library (www.freenect.com) to grab and process the image. A video of the prototype in operation is available at www.youtube.com/watch?v=7Szn3rDRzdo.

DIGITAL HOUSEKEEPING BOOKS

Customer loyalty programs will make extensive use of pervasive computing technology in physical retail spaces. The resulting data on customer behavior could lead to the revival of digital housekeeping books, which have been popular for more than 150 years in analog form. Such books could learn our preferences and help to resupply our households with goods according to our needs.

Instead of simply using sales data to improve supply and analyze demands, retailers could reap enormous rewards by returning this data to their customers. However, such data would be of no use if presented to average consumers in the format currently used by data warehouses. Stakeholders along the supply chain often use specialized terms and identifiers to refer to their products, and retailers would need to replace these with meaningful names and categories.

Recommendation engines could use this dataset to highlight interesting buys or to target special offers. It's easy to envision services that suggest additions to customers' weekly shopping list or answer simple questions like "How much would it cost to switch to organic food?"

Figure 2. Interactive fresh food counter: (a) system setup with scale (indicated by the circle) and Microsoft Kinect camera installed 2.5 m above the counter (indicated by the upward-pointing arrow); (b) the scene as captured by the RGB camera (right) and the depth view (left).

Retail will undergo major technological changes in the near future. Digital signage, shelf and other in-store sensing systems, and increasingly sophisticated shopping-related applications for customers' mobile devices will alter the face of retail as we know it today.

Although there are risks associated with these changes related to the privacy of customer data and the security of data maintained in retailer data warehouses, information about products, their origins, and the way they have been manufactured will also become more easily available (K. Pramatari and G.I. Doukidis, "New Forms of Collaboration and Information Sharing in Grocery Retailing: The PSCO Pilot at Veropoulos," *J. Cases on Information Technology*, vol. 7, no. 4, 2005, pp. 63-78). Price transparency will increase dramatically, and it's not unlikely that physical retailers will use digital price tags to, for example, compare their prices to those of other stores or online retailers. To retain customers' trust, stores will then have to compensate for higher prices by providing additional services or guarantees.

Invisible computing will help retailers provide better service and will let consumers make more informed choices about what they buy. ■

Antonio Krüger *heads the Innovative Retail Laboratory at the German Research Center for Artificial Intelligence (DFKI), Saarbrücken, Germany. Contact him at krueger@dfki.de.*

Johannes Schöning *is a senior researcher in the Innovative Retail Laboratory at DFKI. Contact him at johannes.schoening@dfki.de.*

Patrick Olivier *leads the Culture Lab's Human-Computer Interaction Group in the School of Computing Science at Newcastle University, UK. Contact him at p.l.olivier@newcastle.ac.uk.*

Editor: Albrecht Schmidt, University of Stuttgart, Germany; albrecht@computer.org