Challenges and Opportunities for Embedded Computing in Retail Environments

Kunal Mankodiya, Rajeev Gandhi and Priya Narasimhan

Department of Electrical and Computer Engineering, Carnegie Mellon University, Pittsburgh, PA, USA
kunalm@cmu.edu, rgandhi@ece.cmu.edu, priya@cs.cmu.edu

Abstract. In the retail industry, real-time product location tends to be a multi-million-dollar problem because of seasonal restocking, varying store layouts, personnel training, diversity of products, etc. Stores maintain planograms, which are detailed product-level maps of the store layout. Unfortunately, these planograms are obsolete by the time that they are constructed (because it takes weeks to get them right), thereby significantly diminishing their value to the store staff, to consumers, and to product manufacturers/suppliers. The AndyVision project at Carnegie Mellon focuses on the fundamental problem of real-time planogram construction and planogram integrity. This problem, if solved correctly, has the potential to transform the retail industry, both in the back-office operations and in the front-of-the-store consumer experience.

Keywords: Retail operations, planogram, retail technology.

1. Introduction

For decades, the retail industry has been slow to adopt technology and has focused on fairly traditional technology, such as point-of-sale terminals, barcode scanners, loyalty cards and automated checkout. However, with an urgency to remain competitive in the face of the continual rise of online retail, brick-and-mortar stores want to make their environments more experiential and less staid. Increasingly, retailers are shifting from pure product lines towards ecosystems (McKinsey, 2000) of inter-related, distributed products, services and real-time information, including cross-channel (mobile, web, store, etc.) interactions. There is a push towards *making retail more personalized for the connected shopper in the connected store*, with customer behavioral data, social relationships and in-store/cross-store technology becoming key assets for retailers. Embedded computing has the power to transform the retail landscape. The *stakeholders here are both the shoppers and retail operations* in the back-office.

Digital retail technology can be used to meet shoppers' demands for efficiency, speed, improved customer service, as well as their desire to be more informed and socially connected, while simultaneously addressing the retail industry's needs for increased growth, increased basket-size ($$ of revenue per customer visit), reduced store staffing, improved back-office operations, and increased stickiness i.e., breeding customer loyalty by differentiating themselves from other retail stores. For example, retail stores have long wanted to improve customer service without having to add payroll costs through more store staff. This can be made possible through the strategic use of embedded computing at multiple points in the retail ecosystem—networked digital signs to detect shoppers' interest and engage them in purchases, in-store localization to determine the precise in-store locations of shoppers and products, sensors to track in-store traffic patterns, crowd-sourced analytics (from shopping history, social networks and other stores), mobile devices in the hands of shoppers to allow them to obtain information in real-time, robots to interact with customers and assist them at the point of purchase, etc.

"The holy grail of retailing – being able to offer the right product in the right place at the right time for the right price – remains frustratingly elusive" (Harvard Business Review, July-August 2000) still conveys the complete message of most retailers' day-to-day challenges. The retail industry is one of the most dynamic and influential industries in global economy. In the U.S., the retail industry represents about 40% of the Gross Domestic Product (GDP) and is the largest employer (Fisher and Raman, 2001). The intensified competition that the retail industry faces with the emergence of increasing numbers of new players in both the local and global markets has forced retailers to critically examine and redesign both their operations and marketing strategies (Perdikaki, 2009). To remain competitive, many retailers have differentiated themselves by designing enhanced in-store shopper experiences and other strategies to distinguish themselves from their competitors. Moreover, retailers must constantly strive for excellence in operations; extremely narrow profit margins leave little room for waste and inefficiency. Such practices have provided a fertile ground and new context for research as well as technological interventions in the retail-operations space.

In this paper, we present the current problems of retail operations and also propose a technological model as a solution.

2. Retail Operations

Every time that a shopper enters a store, his/her shopping experience has, in fact, been extensively planned, from the items that he/she sees immediately for sale at the entrance, all the way to the layout and design of the entire store. The decisions of planning and stocking are orchestrated by the retail-operations staff, who are closely concerned with the day-to-day functioning, operations and maintenance of the store. The retail-operations staff typically include sales clerks, check-out cashiers, supplier managers, sales people and floor managers; these roles are largely present in all stores in some form or the other, including both small stores with only a handful of workers and large chain stores with hundreds of employees. Figure 1 shows the different activities and aspects of retail operations.

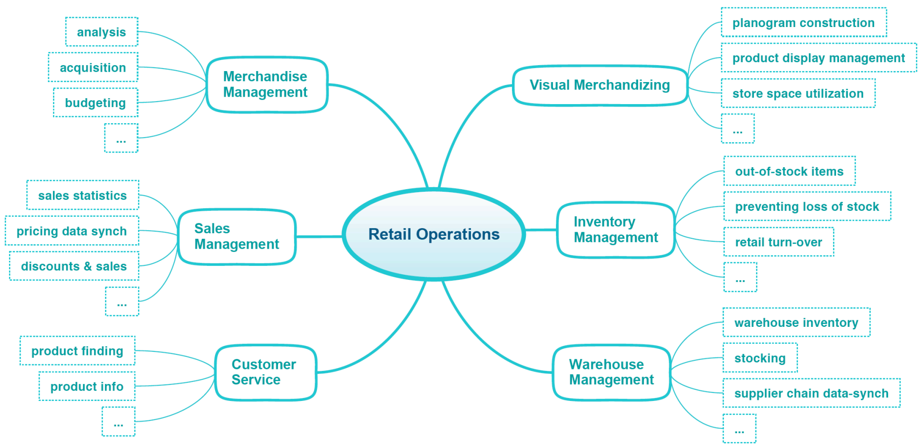

Fig. 1. Different aspects of retail operations.

Merchandise Management

The primary function of any retail store is to sell merchandise; therefore, merchandise management is a key activity of the retail operations. Merchandise management involves in-depth analysis, planning, acquisition, handling and budgeting as related to merchandise (Gaffney, 2000):

- Retailers must correctly analyze their customers and their needs.
- Retailers must plan for proactively ordering merchandise to be sold in the future.
- Retails must procure merchandise from the appropriate suppliers and distributors.
- Retailers need to handle different categories of merchandise, schedule the appropriate time for promotion and display, as well as the right absolute locations (front of the store, aisle end-caps, back of the store, etc.) and the relative locations (i.e., next to which other kinds of products).
- Budgeting is an essential part of merchandise management on multiple levels, including restocking, redoing the store layout, seasonal needs, etc.
- Retailers must be able to perform inventory counts, on a sufficiently regular basis and with sufficient accuracy, in order to provide store audits, to ensure supplier compliance, to enable efficient restocking, etc. This is particularly the case for stores that are subject to restocking and planogram changes due to seasonal variations.

Visual Merchandizing

Visual merchandising is the activity and profession of developing floor plans and three-dimensional displays in order to maximize sales (Wetz, 1995). Both goods and services can be displayed to highlight their features and benefits. The purpose of such visual merchandising is to attract, engage and motivate the customer towards making a purchase. A "planogram" is often widely used in today's retail stores as a means of visual merchandizing. A planogram is a detailed visual map of the store's products that indicates the placement (down to the aisle, shelf and height of the shelf) of products in order to maximize sales and to provide the optimal placement for suppliers (Oxford Dictionaries, 2011). Real-time planogram integrity is a significant problem for retailers.

Inventory Management

Inventory is a list of goods, materials or products, available in stock by a store (Saxena, 2009). Retail inventory management is the process and methods used to keep track of the stock in a retail store. These methods control everything from ordering, shipping, receiving, tracking inventory, retail turn-over, and storage. Retail inventory management can help keep a store's profits at a steady margin as well as reducing theft and loss of inventory. Many retail stores lose money every year because they lack a successful inventory management system in place. In later sections, we will discuss further on challenges associated with current retail inventory management system.

Warehouse Management

The warehouse management is a process of relevant warehousing activities such as product receipts, product issues, deliveries, internal and external stock transfers, product replenishment, warehouse inventory, supplier chain data synchronization, etc. The warehouse management is a huge and complex task, therefore mostly requires separate staff dedicated to run the warehouse.

Customer Service

The functions of customer service are very fragile, as they concern direct and indirect contact with store customers. Goals of customer service are to ensure meeting the needs of store customers with satisfaction and hence to maximize the sales. Retail customer service must:

- Provide efficient service to customers,
- Reduce waiting period at check-out counters,
- Reconcile transactions,
- Help customers find the desired product in the store and
- Furnish further information of the product, if asked.

Sales Management

The field of sales management involves the activities such as coordination of sales distribution, analyze and generate sales statistics, handling quotes and customer data decision-making for sales and discounts, etc.

The functional aspects of retail operations are highly interconnected and disturbance in one of the aspects can affect retail operations in whole and reduce store over-all earning. It is beyond the scope of our current work to address each aspect of retail operations. In this paper, we are focusing on problems of real-time planogram integrity, as related to inventory management, misplaced-item tracking and real-time information to the shopper and to retail operations.

3. The Role of a Planogram in Retail Operations

As consumers become active in more and more activities, they have less and less time available to shop in stores. Seizing the opportunity to create one-stop shopping environments to facilitate this experience, retailers are reacting by increasing store size to increase product assortments and categories. With larger product assortments, additional categories and more space for consumers to navigate, it is vital for retailers and vendors to direct and influence consumers' purchases. Thus, a planogram has become a vital tool to achieve consumer-centric store layout and product assortment in the shelf.

Retail stores keep track of their inventory through the concept of planograms. A planogram is a retailer's blueprint, which visually represents how the merchandise physically fit onto store shelf or fixture to allow proper visibility and price point options (Ray, 2010). A planogram displays how and where specific retail SKUs (stock-keeping unit) should be placed on retail shelves, racks, fixtures in order to increase consumer purchase. Fig. 2 shows different examples of planograms based on merchandise category.

(a) (b) (c)

Fig. 2. Examples of planograms for (a) beverages (Source: Beverage, 2011), (b) clothes (Source: Cloth, 2012), and (c) a store (Source: 3D-planogram, 2012).

Planograms attempt to capture the absolute physical locations of an assortment (e.g., all hot beverages), the relative locations of items in an assortment (e.g., the relative locations of hot cocoa, tea and coffee), the amount of space allocated to each category (e.g., coffee), and each type of item (e.g., Starbucks coffee) within the category. Planograms can be store-wide (entire map of the store), aisle-specific (map of the refrigeration aisle), shelf-specific (map of the cosmetics shelf) or category-specific (map of where all coffee products are distributed in the store). There are multiple purposes for planograms:

- Retail operations: To help the store managers and store clerks know where items are located physically in the store, to keep track of inventory, to know where misplaced items should be located.
- Product placement and marketing decisions: To help the store decide where to place products, particularly new ones that the store is promoting. This helps the store decide how much to charge the vendor for product placement. The amount of available shelf space (particularly at key revenue-generation locations, such as

eye-level or at specific aisle end-caps) available is a marketing/revenue-based decision that the store must make on a regular basis.

- Customer experience: The appropriate layout of products can enhance "brand stickiness" and customer satisfaction. For example, ensuring that all associated product items (even if they are very different items and from different vendors) are within close proximity of each other is likely to reduce customer walk-aways rather than attempting to locate products by vendor or by type of item. For example, locating all baking-related items together, even if the vendors and items are diverse, is likely to improve the customer experience.

Fig. 3. Basic attributes of a planogram (Source: Attribute, 2012).

Basically, the design of planogram happens when the merchandise & assortment planning of a retailer transforms into space planning. A retailer plans the assortment based on several sales strategies, and that can then be translated into store-shelf planning as well. As shown in Fig. 3, there are two basic attributes of a planogram: facing and depth. Facing is the number of units of that particular SKU displayed in the front row of the shelf. Depth is the number of units of that particular SKU shelved one behind the other.

Apart from the basic attributes, there are other various important parameters, which are generally considered for SKU assortment and reflect the complexity of a planogram:

- Category of the SKU, e.g., Coke 300 ml can is affiliated with the Soft Drink Category, Cola Sub Category etc.
- SKU Details–SKU Name, UPC Code etc.
- Dimensions of the SKU - height, length, width, etc.
- Fixture details - type of fixture, location in the store, etc.

4. Challenges Associated with Retail Operations

Planograms are the result of much thought, research and effort to achieve a sales-and-profit goal. A retail study suggested that independent retailers can increase unit sales by 21%, sales by 12% and gross profit by 7% by maintaining planogram integrity (Food Distributors International, 2000).

Planograms get out-of-date due to several reasons: restocking, new products, seasonal changes in products and layouts, the last of these being fairly significant. For example, the layout of most supermarkets changes significantly in the month from Thanksgiving to Christmas, not just in terms of the items that are being displayed or promoted (e.g., cranberries during Thanksgiving vs. fruit-cake during Christmas), but also the layout of the store itself, particularly what is prominently displayed at the entry/access points of the store.

Stores construct planograms today in a time-consuming, manual and error-prone (not to mention, antiquated) manner. Incredibly, stores employ store clerks for manual walk-through and inventorying, on a shelf-by-shelf basis, at off-peak times in stores. This process, especially for large supermarkets, can be a significant, multi-week undertaking. The main problem is that a retail store planogram is often obsolete by the time it is fully constructed, lowering its utility, both for store operations as well as for revenue-generation and marketing.

Planogram Compliance

As one might imagine, implementing a store planogram is the toughest part of the retailing process. Retailers need to ensure that the new planogram arrived from the headquarters is being implemented in the store correctly. This verification process is called planogram compliance (Ray, 2010). Compliance with planograms is important, since optimal product placement can increase profit by up to 8.1% (Bishop, 2000). Planogram compliance is reported back to merchandising management and even nowadays to supply chain (Banker, 2011).

The research for ECR (efficient consumer response) in Europe found that 30% of the consumers would either substitute another brand or not buy at all, when their desired item is not found on the shelf. In 2002, Procter and Gamble (P&G)'s research showed that retailers lose 11% of sales due to out-of-stocks, and that same-brand substitutions win back less than 25% of those lost sales for a manufacturer (Procter and Gamble, 2002). Envisioning this problem, P&G embraced an approach "designing a supply chain from the shelf back", which generated $1B in 2004 (Smith Pole, 2007). In this approach, supply chain works together with retailer to avoid the problems of out-of-stock items and temporary voids. In order to integrate such an approach, there are many challenges including cost of implementation for a technology in the shelf. There does not exist any reliable and cost-effective technology that can report planogram compliance to a supply chain in real-time.

Inventories

The average food retailer stocks 15000-60000 SKUs in thousands of categories and other retail channels are similarly glutted with items, a state of affairs exacerbated by approximately 10,000 new items introduced at retail every year (Industry Overview, 2010). The sheer volume of items strains the inventory-management systems for retailers and manufacturers alike, and drives up costs throughout the supply chain, including the retail, backroom, and warehouse levels (Byrnes, 2005).

Inventory-record inaccuracy, the discrepancy between the recorded inventory quantity and the actual inventory quantity physically available on the shelf, is a substantial problem in retailing. DeHoratius and Raman 2004 (Raman, 2004) found inaccuracies in 65% of the nearly 370,000 inventory records observed across thirty-seven retail stores. They identified several reasons for the 2 inaccuracies including replenishment errors, employee theft, customer shoplifting, improper handling of damaged merchandise, imperfect inventory audits, and incorrect recording of sales. A lack of inventory record accuracy clearly can reduce retail profits due to lost sales and labor and inventory carrying costs, which may run as high as 10 percent of existing profits (Raman, 2001).

In-store Product Location Finding

According to the Wall Street Journal, the average user at a Wal-Mart Supercenter spends 21 minutes in the store, but locates only 7 of the 10 items on his or her shopping list (Wall Street Journal, 2007). Due to the same problem, stores like Home Depot and Best Buy are implementing measures to assist users in locating products, speed their checkout, and make their shopping experience less frustrating. Many consumers find this basic problem to be more frustrating in a food market where there are very few sales people roaming the aisles.

Product location can be even more frustrating in a grocery store where there are usually no sales people manning the aisles and very few stock attendants on the sales floor. Except for the addition of specialty departments such as bakeries, gourmet foods, and prepared foods, the basic grocery store design has not evolved much from its original configuration that assumed users would walk up and down every aisle on every visit because they would only shop once a week to stock up.

Currently, there is no legitimate solution for in-store product location finding. Shoppers generally need to rely on store staff to navigate them to the desired item. In case a shopper is unable to find a store staff, he/she might leave the store with disappointment and hold bad shopping experience. Eventually, the retail store looses the customer due to it inefficiency in providing production location service.

5. Andy Vision: Transforming In-Store Retail Operations

Today, a planogram is a software platform that facilitates retailers to design store plan, fixture placements and SKU assortment planning. The complexity of the planogram software varies from store-to-store and shelf-to-shelf. There are numerous software packages in the market for planogram design including the 3D modeling of the store. The major problem is not associated with generation of the planogram, but with planogram integrity and compliance. First, a store receives the planogram from its headquarters or designs its own planogram, and then, the store staff have to regularly verify the product locations with their assigned locations in actual planogram. Planogram integrity or compliance check is the painstaking task of going from aisle-to-aisle and shelf-to-shelf, and assuring the product placement and its quantity. There is a close similarity between the methods of planogram compliance check and manual inventory count (often called "store sweeps"). In both methods, the store spends significant amount of time and money to ensure the quality of the retail operations.

There have been consistence efforts in the field of planogram technology; PlanoPad (Planorama Inc., USA) is a tablet-based planogram solution for planogram creation and compliance. ShelfSnap (ShelfSnap™, USA) is a camera based planogram compliance solution, which offers four-step approach; taking a photo of a shelf, transferring photos to the web, processing the data at server and providing data analysis. There are other number of similar solution providers for planogram design and compliance in the market. However, there is no existing technology, which by-passes the human for checking planogram integrity and automate the process.

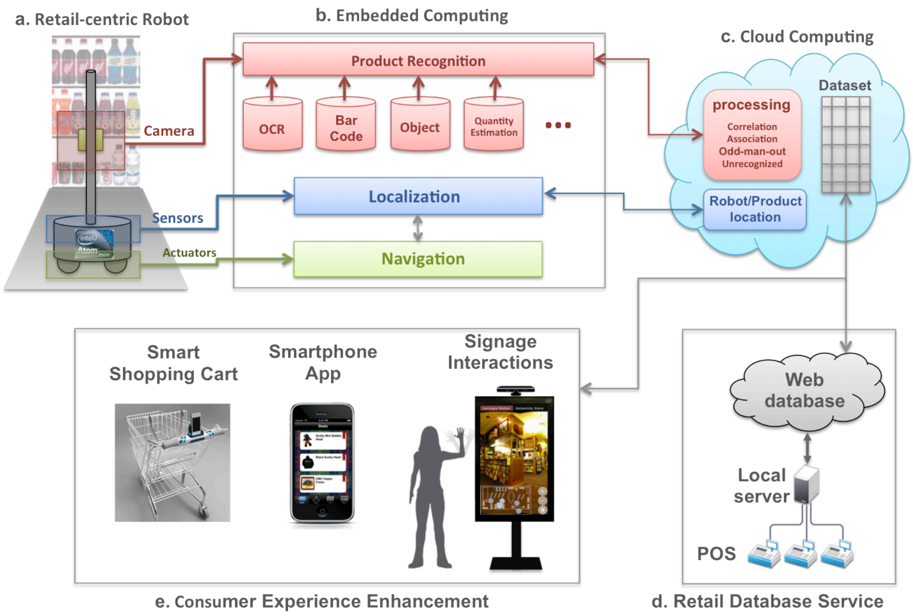

Fig. 4. AndyVision's automated planogram construction: (a) retail-centric robot, (b) embedded computing on the robot platform for product identification and robot localization, (c) cloud computing for accessing retail data base and advanced processing for product recognition and localization, (d) retail's existing database service, and (e) consumer experience enhancement through gesture-driven signage interaction and smartphone application.

AndyVision – An Approach for Automated Planogram Construction

The AndyVision project at Carnegie Mellon University aims to automate the process of retail planogram construction by deploying a retail-centric robot embedded with sensors, localization capabilities, and cameras. The robot scans the store aisles and generates real-time planograms for compliance check and inventory tracking. A cloud-computing platform provides the infrastructure for the big-data consumer-analytics processing as well as the data-intensive image stitching and image search/retrieval. In this approach, we also aim to enhance consumer experience via store digital signs and smartphone app. Shoppers can interact with the constructed planograms on the digital sign through intuitive hand and body gestures (and touch-based interactions, if needed) as well as browse the store products on a store mobile app. The architecture shows the unique capabilities of embedded-to-cloud interactions, and the power of enabling such interactions for transformative retail experiences.

Retail-centric Robots

A recent report by the International Federation of Robotics found that 6.5 million robots serve humanity around the world (IFR, 2008). Large portion of the robots are used in the industrial heavy-duty environments. Recently, there has been increase in domestic application robots such as robotic vacuum cleaners. Retail warehouses of Gap, Amazon, Zappos and Stapes are being populated by massive autonomous robotic systems to pluck products from their shelves and provide in-house transport (Wired, 2009). Japan's Advanced Telecommunication Research Institute demonstrated usefulness of a humanoid robot as a shopper's assistant with grocery purchase (PhysOrg, 2009). Currently, there is no mobile robotic technology available, which can help retail operations to construct the planogram and its integrity.

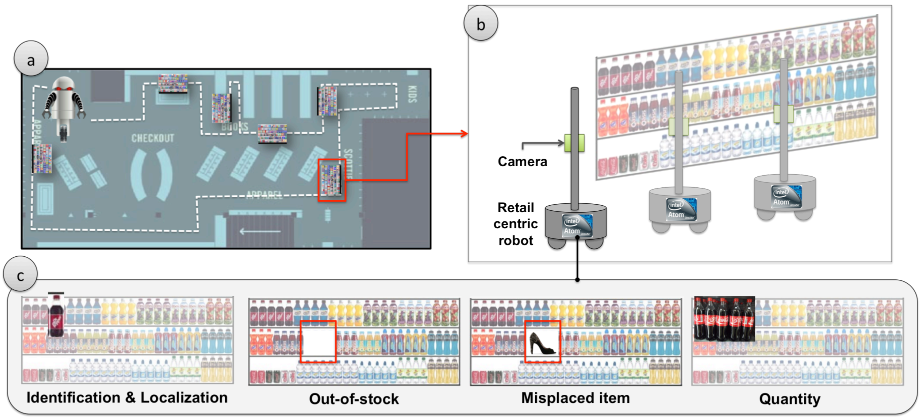

Fig. 5. AndyVision's robot (a) navigating inside a retail environment, and (b) scanning the products on a store shelf. Also shown are (c) use-cases requiring planogram integrity that AndyVision currently targets.

As shown in Fig. 5a and 5b, our current focus is to develop a retail-centric robot, which can freely navigate in a retail environment and scan aisles to automate the planogram construction. A camera integrated on the robot captures images of a retail shelf, which hold valuable information for retail operations such as product locations, products out-of-stock, misplaced products, product volume count, etc. These images also provide excellent platform for supply chains for checking the planogram compliance for their products, in which supply chain can get information on their products assortment, shelf-level placement, stock volume and more analytics in timely manner.

Embedded Computing

AndyVision's retail-centric robot is equipped with cameras for scanning retail environment, sensors for precise localization and actuators for in-store navigation. These sets of modules on the robot require on-board embedded computing to accomplish a huge task of planogram automation.

Product Identification

Previously, it has been noted that a typical food store stocks 15,000-60,000 SKUs on their shelves (Industry Overview, 2010). These SKUs vary from canned/bagged/boxed items to loose form. Identifying each and every item on the shelves by capturing an image is a challenging task and being under massive development. There are very few academic research groups, who pursue a task of in-store grocery identification, but with a different field of application. GroZi is an assistive technology for blind people to help them identify a product in the store and uses a computer vision approach for their technology (GroZi, 2007). Identifying a product in the store certainly needs integration of multiple techniques in computer vision:

- Optical Character Recognition (OCR): The OCR converts images with texts into machine-encoded text and can help identifying the product based on their name-tags on the product package. The name-tags or logos of the brands are normally unaltered and hence are a good source of information for categorizing a product.

Fig. 6. OCR for brand names.

- Object Recognition based on attributes: Items such as loose vegetables/fruits, caps, purse, shoes etc. generally don't carry an identifiable logo or text and hence require different approach to achieve object detection with consideration of size, shape, color, texture, contour and other attributes. Fusion of various attributes has been shown to be powerful cues for object recognition (Bileschi Wolf 2005). Recently, Toshiba Tec., Japan has adopted a computer vision technology for fruit and vegetable detection at check out counter in order to avoid inputting the numbers (Toshiba (2012)).

Fig. 7. SKUs for object recognition based on different attributes.

- Template Matching:
  A method for template-based recognition of products/items includes capturing an image of the item packaging and extracting one or more attributes from the image. The attribute(s) is(are) used to find a matching template in a template image-set of grocery items. The matching template is then used to extract product information from the image. The web contains an immense collection of structured and unstructured image databases and offers the potential to generate useful models for image recognition and categorization (GroZi-120 Database, WebMarket Database).

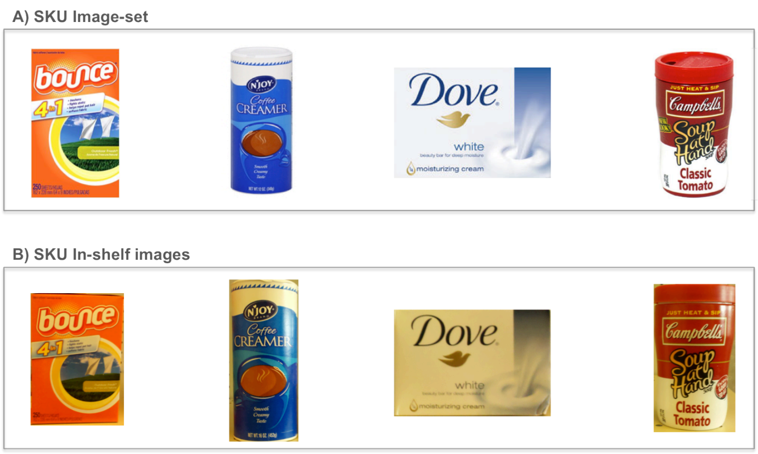

Fig. 8. SKU Template Matching: A) Image-set B) Test images.

Robot Localization & Navigation

We have previously developed high-precision localization algorithms for tracking game-time assets (players, football, cameras, etc.) in the field of play for sports (Narasimhan, 2012). We plan to use this as a starting point for our in-store localization, particularly since our previous algorithms provided fine-grained localization. We describe our starting-point background work here, with respect to retail environments. Precise localization of the robot helps in generating a location-based inventory of the store items and in limiting the latency in product search on the database.

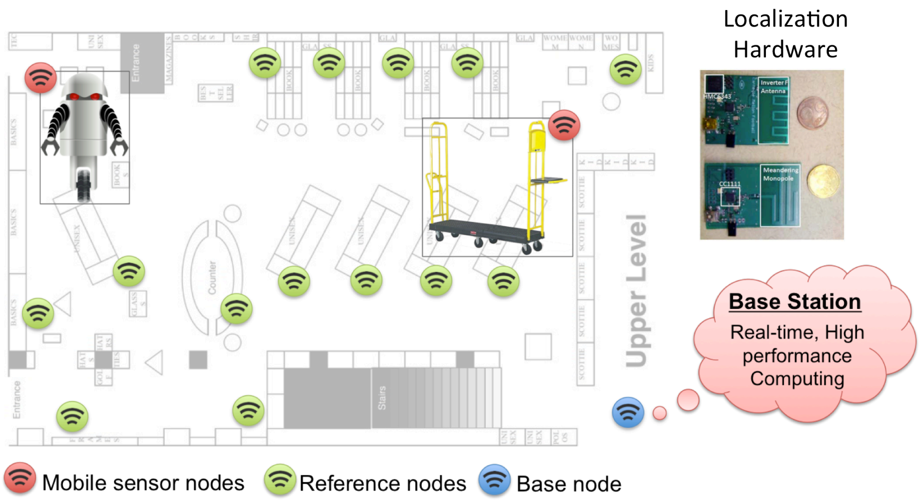

Fig. 9. In-store robot localization technology.

There are three different types of nodes in this system based on their respective tasks - the Mobile Sensor Nodes (MSN) themselves are embedded within the planogram robot and also on restocking carts, the reference nodes are statically placed in the area of interest (the aisles, the aisle end-caps, and strategically located shelves) and a single base-node (a data aggregator, one for every collection of aisles/shelves, based on the specific store layout) collects the data from the reference nodes and transmits it to the cloud for further analysis. The base node gathers all the reference-node information during store operations, restocking times, etc., and estimates the location of the restocking carts and planogram robot, based on signal strength in real-time. The base station is an integral part of the back-end cloud platform.

Cloud Computing Back-End

Retail is a data-intensive environment and hence requires high performing connectivity to servers for data storage, image datasets, constructed planograms and other analytics. We categorize our cloud computing part into following subsections.

- Advanced Product Identification: Previously, we discussed embedded on-board product identification algorithms based on OCR, object recognition and template matching. Unfortunately, it is possible for these algorithms to have some errors, e.g., if on a shelf containing Campbell's cans of soup, some of the cans are turned around so that the labels cannot be read, or if some of the items cannot be identified because the product is placed in such a way that the label cannot be read. We will use cloud-based clustering algorithms to improve the hit-rate of product identification. Related products are often placed together, e.g., all of the Mexican foods are often placed together. If it is not possible to identify a specific product, we can perform clustering of nearby images to provide a coarse-grained classification, even if an exact one is not possible. For example, through a combination of localization, object-recognition and machine-learning, we can tag a bag of beans to be "Mexican red-beans" (or suitable to a Mexican-food recipe) rather than just classify the item as "red beans," by virtue of using object-recognition to detect that the product represents beans, the localization algorithm to recognize that the planogram robot is in the ethnic-foods aisle, and machine-learning/clustering to determine that foods nearby are all Mexican.

- Customized Web-database for Retail Products: The retail store's licensed database is normally difficult to access and doesn't allow the flexibility in-terms of data-type and information structure. Therefore, it is necessary to generate a customized web-service, in which the retail product information can be retried and structured as required for product identification, category, volume, UPC codes and localization. Moreover, it is also necessary to store products attributes and image-sets specifically for computer vision algorithm on product identifications.

Customer Experience Enhancements

People today seamlessly integrate the use of all types of technologies in their lives including the way they shop. As a result, they are more informed and selective about the products and services. In such an environment, the growth of mobile features and device convergence such as smartphones are driving mobile commerce. At the same time, store visits are enhanced via dynamic digital signs and personalization through hand-held devices or the shopper's own phone. These changes provide retailers with the opportunity to drive greater value by making the switch from "talking to" towards "engaging with" consumers and shoppers (Capgemini, 2012). Considering consumers as another channel apart from retail operations, we have stepped on number of technological developments for enhancing shopping experience.

Gesture-driven Immersive Shopping on Digital Signs

Interactive digital signage at retail stores has increased value to the individual's shopping experience. Therefore, digital signage revenue will approach 4.5 billion in 2016 (ABI, 2011). To provide an interactive shopping experience, today's retail digital signs come with various technologies and sensing capabilities; face detection, gesture recognition, a large touch screen, etc. In our development with the digital sign, we are endeavoring to provide technology that facilitates shoppers not only to interact with the digital sign but also to navigate inside the store's 3D environment by hand gestures or using an App on their smartphone. The 3D environment of the store is generated from the planogram captured by the retail-centric robot.

Mobile Shopping Integration

Localizing an in-store item is very frustrating for a shopper. As our primary task is to generate planogram of the store shelves and automate the inventory count by finding a precise location of the items, we can use this information for assisting the shopper to locate an item in the store using their mobile phones. We are exploiting the accumulated data on the cloud and pinpoint the location of the items along with more augmented information.

6. Future work: Pilot Deployment and User Studies

This technology will result in a living, working, fielded embedded system addressing a real pain-point for retail environments, with invaluable data from real users, developed and deployed with a willing and eager pilot partner, the Carnegie Mellon University Store. The Carnegie Mellon Store is a multi-purpose retail environment selling textbooks, trade books, merchandise, computer gadgets, university-branded clothing for men/women/kids, toys, trinkets, and student supplies.

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