Capturing Supermarket Shopper Behavior Using SmartBasket

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Abstract. Retail stores make marketing decisions using customer demographic and sales data to determine which customer and product group combination best contributes increased profit. Customer profile and sales data are of great help but they alone do not portray the whole picture. Tracking the location of a customer in a store and analyzing the customer shopping path and marrying the result to customer profile and sales data is of high interest for marketing for the purpose of streamlining store operations, maintaining customer royalty and increasing sales. In this paper, we propose a system for supermarkets that tracks the path of a shopping cart associated with a customer profile to understand the customer shopping behavior. The proposed system uses IR LED plates installed on the carts which are monitored by small and inexpensive in-shelf networked IP cameras. The shopping carts are equipped with a low cost input device that has a monitor to gather customer profile information. The system is integrated with the supermarket's web site to customize the overall shopping experience. The data collected is mined to find out the relationships among product placement, customer profile and product purchase decisions. The system is designed to monitor real time movements of the shopping cart.

Keywords: Customer Tracking, Shopping Behavior, Navigation Patterns, Image Processing.

1 Introduction

Offering the right product, at the right price, in the right place and at the right time to customers is an elusive goal for retail owners. Detecting patterns in customer behavior and understanding the thought process in purchasing decisions is very helpful in gaining competitive advantage. Store owners want to be knowledgeable about their customers' profiles, the relationship between customer profiles and customer shopping habits and the products that the customers want to have in their stores. The amount of time a customer spends in a particular aisle and in which order they visit the aisles are

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of particular interest to the owner. A supermarket owner is also keen on knowing if a product is drawing the attention of the customers or not. It is essential to separate a customer passing by a product group from a customer paying close attention to a product group, even though no purchasing activity has occurred in both. The former case is especially significant because the product simply goes unnoticed and maybe needing a relocation. In the latter, the customer has looked at the product group but chosen not to buy the product which may indicate that a product re-design or a price adjustment is due. Information of this kind is very valuable and cannot be obtained from cash register sales data. It requires tracking data.

Gaining an insight into customer behavior can be achieved by analyzing data from multiple sources. Our goal in this paper is to present a novel and cost effective solution to collect customer location data and combine this data with customer profile and purchase data to make inferences about customer behavior, hence to help the retail owner to develop effective marketing decisions and to determine future strategic direction. This provides a wholesome solution to supermarket business intelligence. The systems also improves the overall customer shopping experience by dynamically adapting customer services and offering individualized service based on customer profile.

Tracking data is collected using in-shelf IP cameras by detecting the IR LED plates installed on the cart. The system also includes a low cost electronic device with a touch monitor and an integrated barcode reader (similar to an entry level tablet PC). This device is also installed on the shopping cart to facilitate interaction with customers for creating their profiles and customizing their stay in the supermarket.

Smart Cart software is implemented using C# and .NET technologies. Processing of the frames is done using open source computer vision library OpenCV [1]. The System Architecture Section presents the architecture and implementation details of the proposed system.

2 Related Work

There are numerous techniques developed to track people and assets especially in inventory tracking and supply chain management [2]-[5]. Some of these are commercial products and some of them are still under development in research labs. One such commercial application from PLUS uses Ultrawide band technology to track people and assets in retail stores and grocery stores real time [6]. This technology can pinpoint the exact location of a customer but is very expensive. Shopper movement is tracked by a camera using face and eye detection in [7]. Computer vision based approaches do not require expensive hardware to implement but use advanced image processing algorithms. Therefore, these approaches do not easily lend themselves to real time monitoring as they require extensive back-end image processing. Their use in retail shops and grocery stores are not as widespread as in the case of RFID based deployments. RFID based solutions usually equip the carts and shelves with readers and store items with tags [8], [9]. The system described in [8] is a comprehensive proposal with rich features however, no real implementation exists. Its cost estimate is also high due to the readers installed both on the carts and in the shelves. Cost of RFID tags is negligible. However, the cost of the readers makes RFID based deployments an issue. It is also not possible to accurately determine if a shopping cart is facing one product group or another since the cart can be anywhere within the range of the reader. Increasing the number of readers do not solve the problem, since overlapping readers will register a reading simultaneously.

The analysis of tracking information in retail shops, grocery stores and supermarkets has not been explored much. However, there is plenty of work done on navigation patterns in e-commerce [10], [11]. Mining the traversals of on-line shopper using the web logs allows online retailers to get an insight into online purchasing behavior and enables the web designer to better design their web sites. The same approach is used in [9] to discover traversal patterns in retail stores. That study needs further work as it needs to use real data instead of a computer generated data set.

Our approach presented in this paper is similar to the one in [9] which tracks carts instead of people. This is in contrast to the system described in [7] which tracks people. On the other hand [7] uses a video based system similar to the system proposed in this paper whereas the system in [9] uses RFID. Our system strikes the right balance between cost effectiveness and overall system performance, furnished with many customer oriented features.

3 System Architecture

The proposed system uses IR LEDs and IP cameras to track the shopping cart. An infrared LED is a type of electronic device that produces light in the infrared part of the spectrum just below what the naked eye can see. Although invisible to human eye many cameras can see infrared light. IR LED plates are installed on the cart and are detected by low cost in-shelf cameras. Fig. 1 depicts a snapshot of a LED plate on the cart taken by an IP camera. Cart ID is encoded by using different LED configurations. The on or off status of a LED indicates the cart ID. For each product group within an aisle an in-shelf camera detects the presence of light emitted from the LED and after processing the captured image, determines the Cart ID. The IP cameras are wirelessly connected to a server that processes the captured images. The store server is the central hub for all data exchanges. Its primary job is to receive images captured and sent by the cameras, process those images and store the results to the database which is later used in path mining. Other hardware components of the system consist of a tablet PC like device with a touch screen monitor similar to the one shown in Fig. 2 and an integrated barcode reader. This device will be used to interact with customers for creating their profiles and personalizing the shopping experience. It communicates wirelessly with the server as well. Fig. 3 shows the overall architecture of the system.

The SmartBasket system consists of three software modules which are responsible for detecting the cart ID, customer interaction and transaction mining.

Fig. 1. Shopping cart installed with an IR LED plate

Fig. 2. Shopping cart equipped with an input device

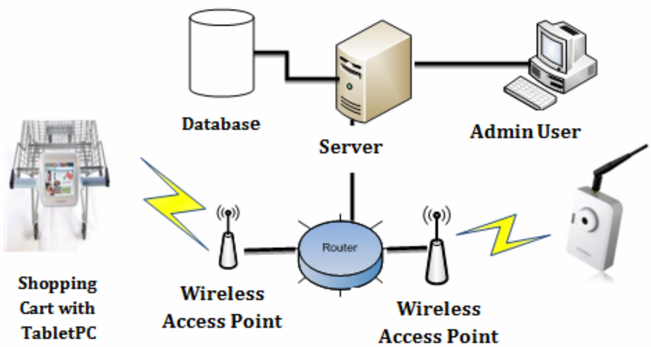

Fig. 3. SmartBasket architecture

1) Shopping Cart Detection Module
2) Shopping Cart Customer Application (for the customer)
3) Transaction Mining Module (for the retail owner)

A customer, before begins shopping, interacts with the tablet PC using Cart Application installed on it which creates a customer profile using the customer's demographic information. The customer is also presented a voluntary pre-prepared survey to collect customer opinion about shopping experience. The Cart application associates the cart with a customer as shown in Fig 4. This module also offers personalized shopping experience by advising or warning about other products, offering promotions and directing the customer to product location.

Customer demographic information is stored in the database; therefore standard security measures are applied to protect the wireless network infrastructure, store server and the database against sniffing and unauthorized access.

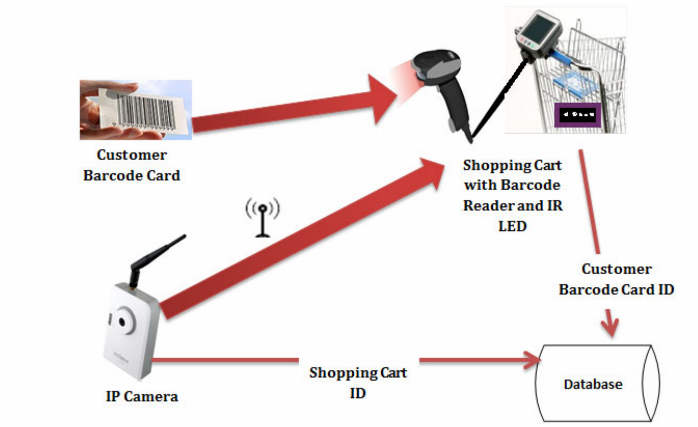

Fig. 4. Shopping cart and customer ID association

3.1 Shopping Cart Detection Module

Each shopping cart is equipped with an IR LED plate to identify carts. Each LED represents a bit. Therefore, with an 8-LED configuration it is possible to identify 255 carts. When parity checking is used 1 LED would be used for checksum, thus 127 carts would be identified. Fig. 5 demonstrates how an IR LED plate on a cart is translated into a cart ID. The camera is fully calibrated and strategically located so that an unconstructed view of the LED plate would be captured. The LED plates would be placed at two different locations on the cart. One plate is installed at the base of the cart on the right side and the other would be placed in the front. The image captured by the camera is transferred to the server for processing over the IP network one frame per second. Capturing frequency is configurable and depends on the resolution and color quality of the video frame. A time stamp is appended to every frame to allow the temporal ordering of the frames on the server. This enables the server to perform off-line or batch processing due to network delays. The processing of the images is computationally efficient therefore the system can be used real time.

The processing of the image starts with finding the squares on the image as the IR led plate is in the shape of a rectangle with a predefined width and height proportion. All the contours on the frame must be found in order to find the rectangles. The square detection algorithm extracts the region of interest corresponding to the LED plate by filtering out the noise surrounding the rectangle [1]. The area within the rectangle is applied a threshold to isolate the IR LEDs that are on. Then, the plate is divided into n equal regions where n is the number of LEDS on the plate. A blob detection algorithm is applied to each region. The presence and absence of blobs are mapped into a bit string and converted into a decimal shopping cart ID. After the cart ID is determined the detection module stores *(Cart ID, Camera IP, timestamp)* data into a database.

The next step is to determine the product group location where the shopping cart is positioned at. The IP camera is located such that it can monitor several product groups within an aisle, and therefore reducing the number of cameras used. The position of the LED plate rectangle in a frame indicates the exact location of the shopping cart as shown in Fig. 6. Once the location of the cart and the product group is determined, the detection module generates the quadruplet *(Customer ID, Cart ID, Location ID, timestamp)* and stores it into the database. In reality, data is stored in the database in multiple tables. The quadruplet is computed after performing database joins.

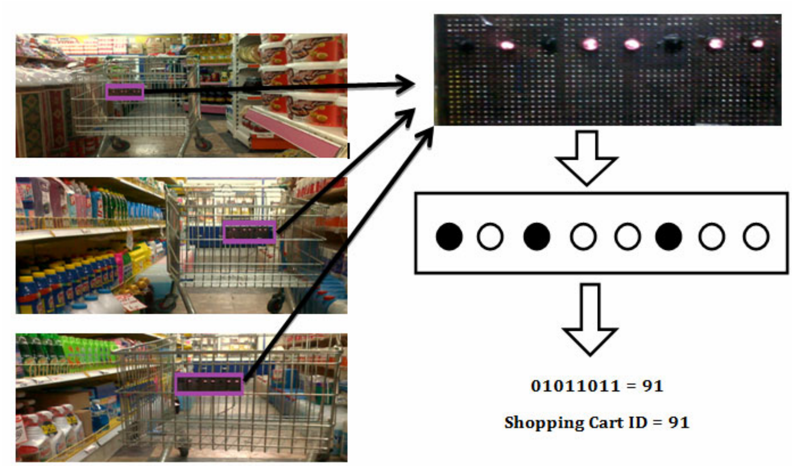

Fig. 5. Detecting cart ID

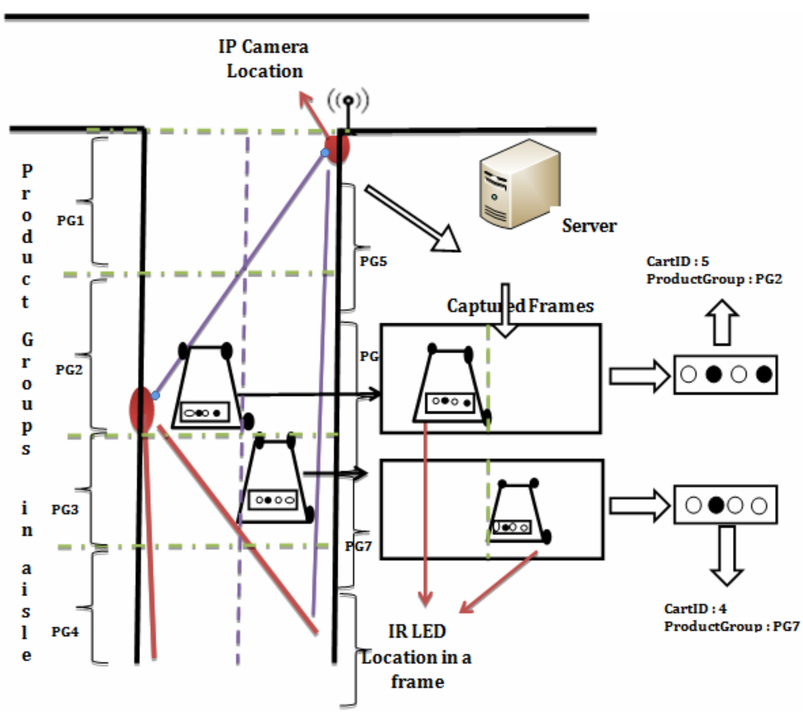

Fig. 6. Finding the location of a shopping cart from the captured frame

The location data stored into the database is verified for consistency. If a cart is not being used by any customer then detection of a traveling cart with that cart ID is erroneous and therefore should not be entered into the system database. In another scenario if a cart is detected in an aisle at time *t*, then it is impossible for that cart to be in a remote isle at time *t* plus one second. These scenarios indicate that either the frame acquired by the camera does not show the LEDs properly or the processing module incorrectly processes the image. In certain cases error correction would be possible, however, it would not be as easy as detecting the error.

3.2 Shopping Cart Application

The carts is equipped with a low cost electronic device with a touch screen monitor that is capable of scanning product bar codes and wirelessly transmitting information to the central server. This device will be activated by the customer upon picking the cart after having their store issued shopping card scanned. This results in establishing an association between the cart and customer profile. Another purpose of this device is to provide a personal and customized shopping experience to the customer as the customer is now "known" to the store. The device will provide product information and promotions tailored to the customer and can even suggest the location of a related product. For instance, the location of the cream will be suggested for those who are planning to purchase coffee. The device will ask the customer short survey questions about the customer's shopping experience. This is voluntary however. Example user interfaces are shown in Fig 7.

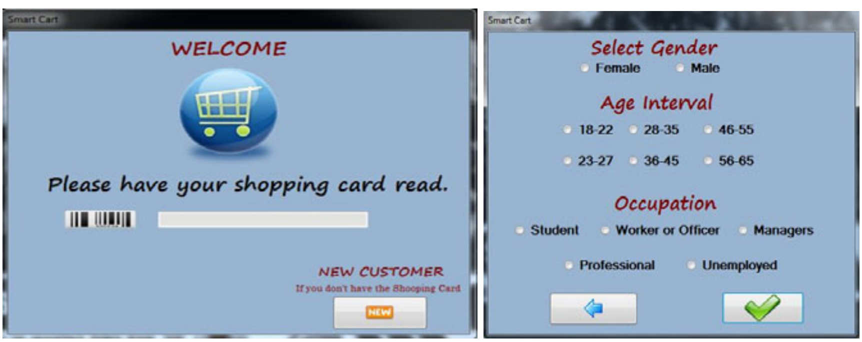

Fig. 7. Sample Shopping Cart Application GUIs

3.3 Transaction Mining

There is a close parallelism between the navigation of a user at an electronic commerce site and a supermarket shopper navigating through the supermarket aisles or sections at a retail store. Web navigation patterns attempt to decipher customer purchasing behavior and reacts to the result by providing efficient access between highly correlated objects, better authoring design for web pages, putting advertisements in ideal places and better customer classification [5], [6]. The very same approach could also be used in supermarket tracking as well. Once a customer completes the shopping at the checkout counter, the transaction mining module will start generating the pair *(C, P)*. *C* is the customer record with attributes such as age, gender and salary and *P* is a set of ordered pairs denoting a path where *P = {(s,i) | s is the segment id housing the product group and i is the product purchased}*. *(s,-)* indicates that no product is purchased from that product group. An example pair would be *((age=30, sex=male), ((baby, diaper) (beverages, beer)))*. For example, if one finds a pattern like the one just given, it would be a savvy marketing decision to place a new beer product next to diapers for its promotion. We define *ΔP* as follows. *ΔP= {(s, i, t) | (s, i) € P and t is the time spent at segment s}*. Then the path *{(s1, i1, 5), (s2,-, 0), (s3,-, 0), (s4, i2, 3))* may indicate that segments *s2* and *s3* went unnoticed. This could be an expected shopping path. However, if product groups, *s2, s3* and *s4* contain related products then a close examination is due to understand the cause, as the products in *s2* and *s3* may be unblocked or not visible.

Based on the study done in [9] - [11], it possible to make various other inferences on the navigation pattern of a supermarket customer. The overall data flow of the system is shown in Fig. 8.

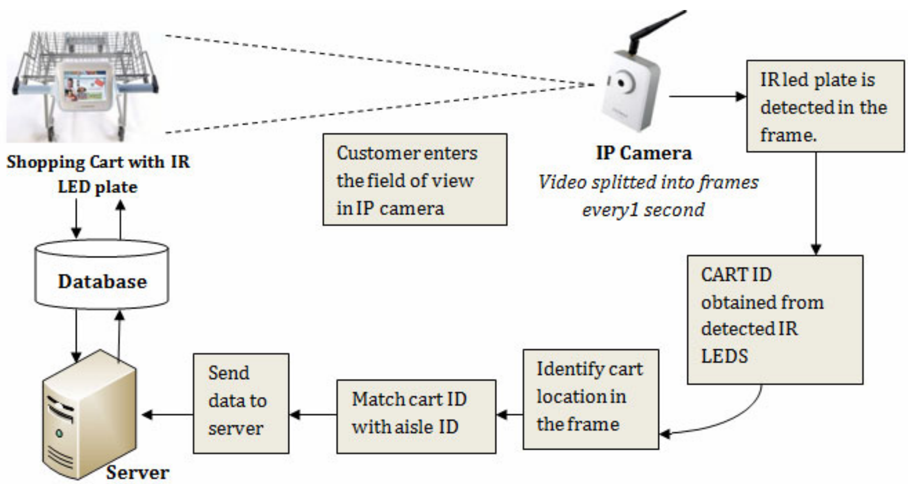

Fig. 8. System Data Flow

4 Conclusion

Customer purchasing habits is an important concern of the supermarket owners [12]. Getting insight into a customer decision making process would provide invaluable information to the owner to offer better and diverse products, provide better customer service and gain advantage over the competitor. In this paper we propose a system that collects tracking information of a supermarket shopping cart and associates location data with customer profile and purchase data to help the owner in marketing decisions and store operations. The proposed system is a video based system that detects IR LED plates installed on the shopping cart. The system is integrated with a tablet PC like device also installed on the cart to personalize the customer shopping experience and expedite the checkout process. The collected data is analyzed to provide analytics and statistics to the store owner for future merchandizing decisions.

Our system is a low cost solution to customer tracking. The cost of an IR LED plate and an IP camera used in the system is less than $70 combined. The item that increases the overall cost of the proposed system is the tablet PC on the cart which is not required for tracking but provides several advantages. It personalizes the shopping experience for customer by offering products of interest or sometimes by warning the customer about some products due to health and dietary restrictions. It provides shopping efficiency by directing the customer to the next product to be purchased. The use of bar code scanner speeds up the check-out time at the cash register and allows payment of the goods even before reaching the check-out counter.

The system's cart ID detection algorithm heavily relies on getting a high quality image with visible LEDs. The lighting conditions and blockage caused by other carts and shoppers may hinder the ability to collect data. This can be rectified by increasing the LED plates on a cart or positioning the camera for minimal interference by the other shoppers.

The cart detection and shopping cart application module is currently in system and integration test phase, as of writing of this paper. The transaction mining module is still under development.

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