Extending Electronic Catalogs for Supply Chain Management

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INTRODUCTION

The supply chain management of goods and services involve multiple trading partners with suppliers/manufacturers and customers at the two ends and wholesalers and retailers in between. Everyone of these trading partners need to determine their requirements, in terms of merchandise, and match them against availability, pricing, and cost of transportation. At every step of the supply chain economics information retrieval is a crucial and recurring process. International bodies such as the International Standards Institute (ISI) and others have designed product codes for standardizing product specification, with the goal of simplifying the search and identification of products in supply chain management. However, such standardization is not feasible in many industries such as fashion design, textile, apparel, and leather (e.g., Abenathy *et al* 1995). Without standardization, it is difficult and sometimes impossible to specify product characteristics in a concise and accurate manner. The typical electronic data interchange (EDI)-based transactions, for example, are limited to thirty-character descriptions, which is far too limiting in many cases.

There are other areas of supply chain management that require efficient and effective search tools for identifying the required merchandise and/or determining the suitability of a particular merchandise for a particular need. Examples include visual quality inspection of leather interiors for automobiles, referring to previous designs from large collections of design sketches in order to create new designs in the apparel industry, and browsing through catalogs for certain designs by customers and retailers.

With the advancement of information technology in recent years, it is now possible to provide technological solutions to searching and browsing for information, the lack of which has mired the process of supply chain management for years. In this paper we describe a methodology for efficient browsing and retrieval of images based on image characteristics. We present the methodology in the context of printed patterns, and discuss its applicability in a broader application spectrum. We also describe with example scenarios how such a methodology can be useful in electronic catalogs that allow the various trading partners to specify their needs, identify required merchandise, and interact among each other, using a ubiquitous virtual medium.

The rest of the paper is organized as follows. In the next section, we describe supply chain management issues, followed by a methodology for interactively identifying an image based on user specification, a language for user interaction, a prototype implementation of a system based on the methodology presented.

SUPPLY CHAIN MANAGEMENT

A supply chain system consists of a number of trading partners that are interconnected through the flow of materials and/or information. As raw material flows downstream from raw material suppliers through the supply chain to the manufacturers, it is transformed into more functional and integrated products with a higher economic value. Further downstream, it flows through distribution channels to retail outlets, and finally reaches the consumer. Information can flow from retail outlets to the trading partners upstream in the form of market forecasts and orders, and also from suppliers/manufacturers to the trading partners downstream in the form of order status and shipment information. In order to meet consumer demand, a large number of suppliers and manufacturers must work together to manage the flow of material and information. Without proper streamlining of the information and material flow in this highly complex supply chain, billions of dollars can be lost in the form of stock outs, defects, mark downs, and inventory costs.

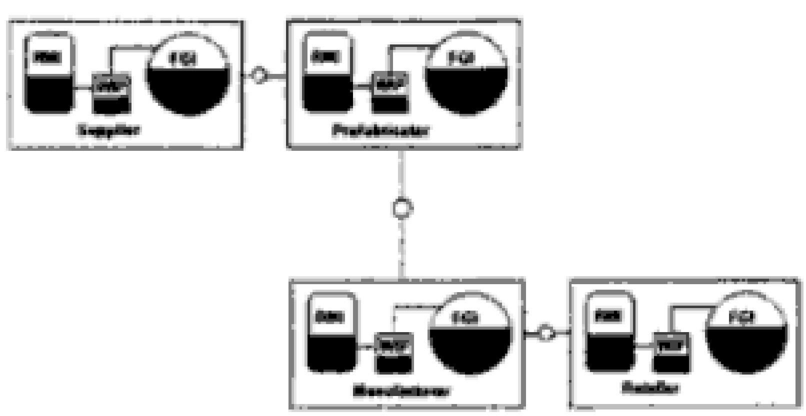


Figure 1. Material flow in a supply chain

Integration of supply chain would require improving the communication between various links in the supply chain. These include market forecasters, retailers, manufacturers, and suppliers of raw materials. A quick response turnaround time would be needed to avoid the "bull-ship" effect on the supply chain (Lee *et al* 1997) in attempting to meet customer demand. A properly designed supply chain should take the following characteristics into consideration:

METHODOLOGY

In this section we describe a methodology that could be used to facilitate integration through increased communication between the various supply chain members. We demonstrate how content-based image retrieval can be useful in this context, particularly for products that have a rich visual content such as textile, fashion design, and home furnishing. We apply the methodology presented in this section to the activities related to downstream members in the supply chain including fashion designers, market forecasters and retailers, and show how the information can be propagated and linked with upstream members such as apparel, textile, and fiber manufacturers. Figure 2 shows an integrated architecture of the proposed system. The system would allow fashion designers to interactively develop new designs by retrieving the appropriate combinations of color, texture, and shapes through mix and match. We characterize color by using the Hue, Saturation, and Intensity (HSI) channels, since this characterization has been demonstrated to be less sensitive than the RGB channel in terms of the variation in the amount of light. Designers can specify the percentage of color in designing a print pattern. Color images are converted into gray scales before computing the texture features. The texture of an image is characterized with the *contrast*, *coarseness*, and *directionality* properties, which are derived from the first-order statistics of the edge distribution (Tomita 1990). Contrast is a measure of local variations of intensity, with higher variation of intensity representing higher contrast. Coarseness is measured with the number of texture elements in a fixed-size window, with a smaller number of texture elements representing higher coarseness. Directionality describes the visual arrangement of elements in a pattern. Four shape parameters are used: *surface regularity*, *form factor*, *roundness*, and *aspect ratio* (Adam, Gangopadhyay 1999). The size is determined by the *area* and *perimeter*, both being user specified with area as the default size parameter.

End users (potential customers) can use an electronic catalog to browse through the apparels, search for a particular combination of color, and texture, and can interactively retrieve clothing that are *similar* to the ones that

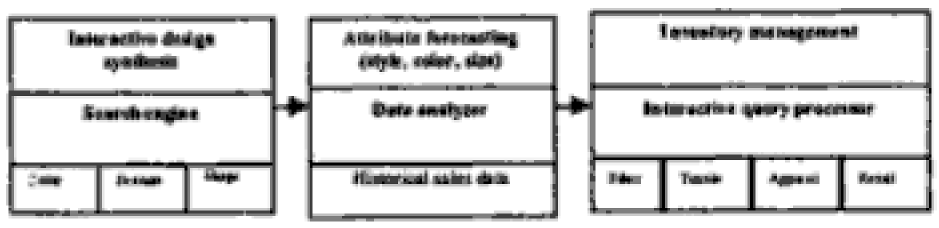
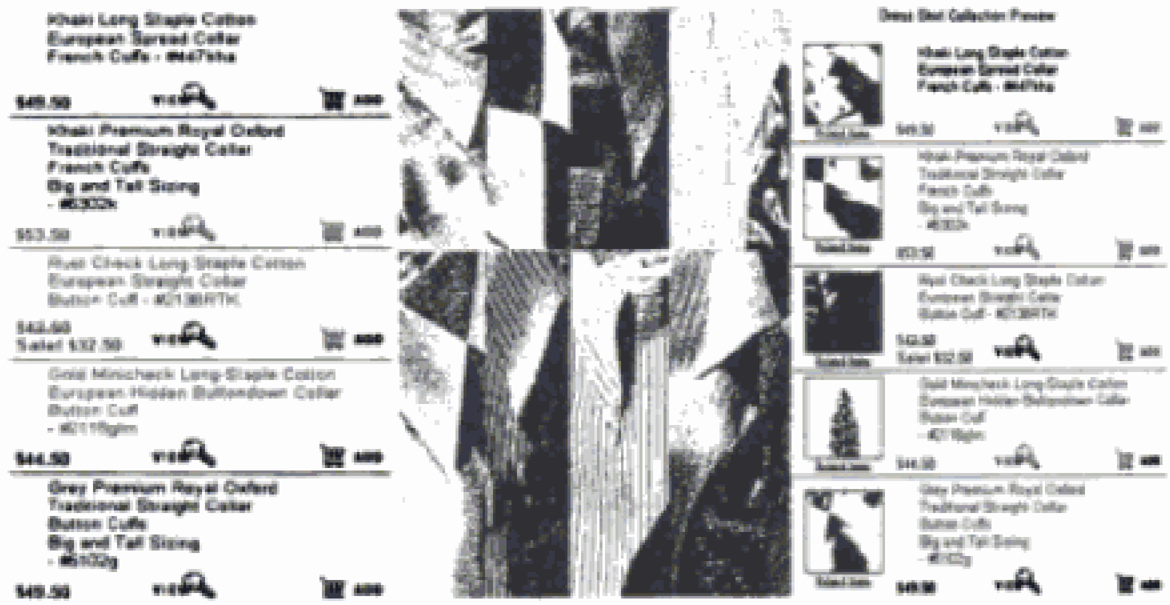


Figure 2. Generic system architecture in apparel industry



a. Text only b. Image only c. Text and image

Figure 3. Three browsing interfaces

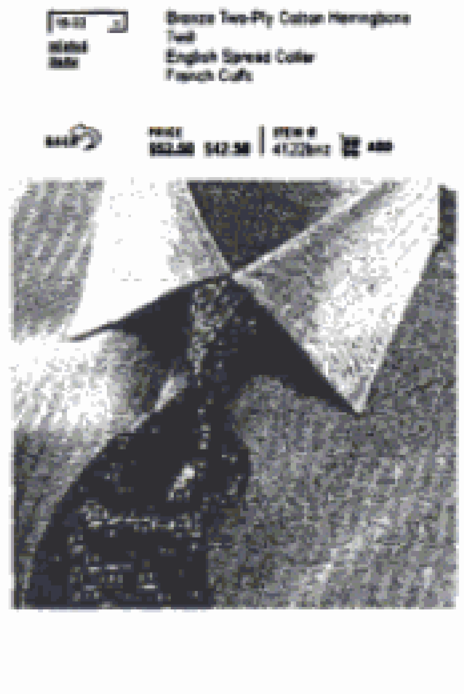
have already been retrieved. We describe the interactions of end-users in terms of *browsing* and *searching*, where browsing refers to the activity of scanning through various items on display and searching implies that the user is looking for one or more items with a specific set of criteria in mind. The system is designed on the premise that good search mechanism would maximize *recall* and *precision*, while a good browsing mechanism would expose the largest range of items in stock with the minimum amount of effort.

- **Browsing:** Figure 3 illustrates three different browsing interfaces in an on-line catalog, where 3a, 3b,and 3c are text only, image only, and text and image interfaces respectively. It is possible to select a shirt from any of the three interfaces and view an enlarged version of it and get more information about. The result of selecting a shirt is shown in Figure 4.

Although Figures 3a-c display information about the same products, the amount of information displayed to the user varies. Figure 3a provides material, style, and pricing information but no visual information about the products. Figure 3c provides material, style, pricing, and visual information about the products, while Figure 3b provides visual only information. In a browsing experience in a brick-and-mortar shopping mall, users typically browse through as many products as possible before selecting a very small subset about which they would like to get more detailed information. This strategy represents a general to specific information collection behavior, where general represents information related to visual cues and specific represents detailed information such as material and pricing information which are typically expressed with alphanumeric data. It is also possible to browse through a large amount of information (number of shirts in this example) using Figure 3b as compared to 3a and 3c. Hence we adopt the image-only interface as the initial browsing interface for our system.

- **Searching:** Searching image data is different from alphanumeric database applications in the sense that the former represents approximate search as opposed to exact match in the latter. Once target image data is retrieved, the user can decide what to discard and what to keep. Furthermore, the user can refine the initial query and perform a more focused search. The user interface should also allow the user to query, evaluate, and refine the search visually. Searching could be performed by color, texture, shape of patterns, or a combination of the above. The methodology for the search is described in more detailed in the next section.

Figure 4. Selected item



Content-based image retrieval:

Content-based retrieval (CBIR) refers to the ability to retrieve data based on the analysis of its content rather than metadata specifications. The usefulness of CBIR has been demonstrated by its numerous applications including satellite images, medical images, handwriting recognition, visual quality inspection, and fashion design and textile products.

We use color, texture, and shapes as the measures of similarity among printed patterns of textile products. In our case, the system does not have any *understanding* of the image content, but is not designed to do pattern matching using the image attributes. The system is designed as a semi-automated tool that enables the user to efficiently browse through numerous patterns, compare them in terms of similarities, and retrieve other patterns based on some similarity measure. This works well in the context of the apparel industry, since there is generally no inherent meaning in the texture patterns and/or color combinations other than visual attractiveness.

Color-based search: We divide the color of an image into the HSI channels, which gives rise to 256 gray scales for each channel, giving rise to a 16M color space. For each image we create a color histogram for each channel, and compute the average, which gives us 256 bins. Color-based search requires comparing the histograms of the sample image with that of the target image. In order to reduce the amount of on-line processing, we preprocess the color similarity of all images and generate a similarity matrix based on color, which is stored as a 3-tuple <*image$_i$*, *image$_j$*, *sim*>, where $1<i<N-1$, $i+1<j<N$, and $i \neq j$, and N represents the number images in the database. We compare the histograms of the image selected by the user (we refer to it as the example image) and the target image by using the methodology described in [Barber 1995]. Let H_e and H_t be the histograms of the example and target images respectively. The element by element difference between H_e and H_t is the difference histogram H_d. The similarity $|S|$ between the example image and the target image is computed by the following formula:

$$|S| = H_d^T M H_d$$

where H_d^T is the transpose of H_d, and M is the symmetric color similarity matrix $m_{i,j}$ represents the similarity between colors i and j in the color spectrum. This method accounts for the perceptual difference between any two pairs of colors as well as the difference between the different shades of a given color.

Image Preprocessing

Every image in our electronic catalog is preprocessed to analyze its content, which is used for supporting the browsing and retrieval of images later on. Since the images are print patterns, we use texture analysis to derive the content information.

We measure similarity between images as the Eucleadian distance in a multi-dimensional feature space. Let us say that there are n features in the feature space F. Then the similarity between any two images, u and v, is measured as follows:

$$d_{uv} \sqrt{\sum (i_u - i_v)^2} \quad (1)$$

i_u and i_v are features of u and v respectively that range from 1 to n in the feature space F. As the first step in preprocessing, we split a 24-bit color image into the RGB (red, green, and blue) channels, the purpose being to measure the image characteristics across all the three channels. In this particular case, we use two parameters: shape and texture.

REFERENCES:

Available upon request from author.