A Personalized Recommender System Model Using Colour-impression-based Image Retrieval and Ranking Method

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Abstract— **This paper points out that achievements in the field of multimedia analysis and retrieval represent an important opportunity for improvement of recommender system mechanisms. Online shopping systems use various recommender systems; however a study of different approaches has shown that they do not exploit the potential of information carried by multimedia product data for product recommendations. We demonstrate how this can be accomplished by a personalized recommender system model that is based on analysis of colour features of product images. We present an approach for extraction of colour-properties of images in order to represent impressions related to the human perception of images. Colour-properties are based on image colour histograms, psychological properties of colours and a learning mechanism. Based on the extracted colour-properties, the method retrieves and ranks the images corresponding to the desired impressions. The architectural framework of the model is based on service-oriented architecture in order to promote its flexibility and reuse, which is important when applying the model to existing recommender system environments. An experimental study was performed for decorative photography domain.**

Keywords- product recommendation; image retrieval; E-business; service-oriented architecture.

I. INTRODUCTION

Online shops provide different Web-based services for customer-product matching and product data representation in order to support customers at their decisions when buying the products. Customer-product matching mechanisms differ greatly based on the amount of effort the customer has to invest in order to find the desired product. The most basic approach that requires the most effort from the customer is catalogue browsing. As customers are often unable to evaluate all available alternatives in great depth, they tend to use two-stage processes to reach their purchase decisions using product catalogues: firstly they screen a large set of available products and identify a subset of the most promising alternatives; secondly they evaluate the latter in more depth, perform relative comparisons across products on important attributes, and make a purchase decision [1]. Other types of approaches are known as recommender systems. Recommender systems help customers find the products they would like to purchase by producing a list of recommended products for each given customer [2]. Schafer et al. have developed a taxonomy of e-commerce recommender systems [3][4] based on two key dimensions: a) the degree of automation, which depends on the effort the customer has to invest in order to get the recommendation, and b) the degree of persistence in recommendations, which depends on whether the recommendations are based on data regarding previous customer sessions with the system or not. One of the most common partially automated recommender systems are product search services where customers enter desired product attributes (search query) and search results comprise those products that correspond to the search query or are the closest match for the search query. An example of a completely automated recommender system is an implicit customer-product matching system. They do not require explicit customer actions, and autonomously recommend selected products to individual customers, for example in the side frame of the Web page.

There are many research contributions in the field of recommendation techniques; examples are [2][5][6][7][8][9][10][11]. They range from very basic, such as presentation of the most popular products, to more advanced, such as web mining techniques [5], collaborative filtering [12], decision tree induction [2], association rule mining [13], etc. However, a study of different recommendation techniques ([2],[5-11],[14-21]) that existing recommender systems techniques do not take into consideration information contained in the multimedia product data. The multimedia product data is used mainly to present the product to the customer after the products to be presented have been selected. We observe that there is an important potential to improve the customer-product matching mechanisms using not only text-based data about the products, but also product multimedia data. In the recent years, advances in the field of multimedia have provided several important results and the potential is there to improve existing customer-product matching mechanisms.

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In this paper we present an innovative model for improvement of recommender systems, using product image data. We have applied the colour-impression-based image retrieval and ranking method [25] to the design of this model. In [25], the colour-impression-based image retrieval method and its system architecture have been proposed for realizing image-colour processing dealing with emotion-aspects of human senses to images. The purpose of our model is not to replace the existing recommender system techniques, but to enhance them by utilizing image based information about products. The presented model uses a method for product image analysis which can automatically determine colour-properties of product images. The extracted colour-properties are used in order to improve the product search results and product recommendations. Colour-properties are extracted based on image colour histograms, psychological properties of colours and a learning mechanism. The method that implements this behaviour has been presented as the colour-impression-based image retrieval and ranking method in [24] and [25]. As far as we know, there is no other product recommendation system that exploits colour-impressions contained within product images in order to improve recommendation results. An important characteristic of this approach is that colour-impressions based on image perception are subjective and pertain to individual customers. Therefore, one of the requirements of this approach is to take into consideration different perceptions of different individuals. The proposed model can be valuable for different companies, especially for those where colour and subjective properties of their products play an important role in product selection for the customer, for example fashion and art domains. We show an example implementation of the model for decorative photography domain.

The remainder of the paper is structured as follows. In section two, we briefly review the colour-impression-based image retrieval and ranking method [24] [25]. In section three, we discuss the image-based recommender system model and how the colour-impression-based image retrieval and ranking method is applied to a recommender system. In section four, we represent an experimental study from the domain of decorative photography. In section five, we give concluding remarks.

II. COLOUR-IMPRESSION-BASED IMAGE RETRIEVAL AND RANKING METHOD [24][25]

In this section, as an image retrieval method for realizing our personalized recommender system model, we briefly review the colour-impression-based image retrieval and ranking method which has been proposed in [24][25]. In this paper, we apply this method to the design of our recommendation system model with product image data. The main feature of the colour-impression-based image retrieval and ranking method is how to deal with the colour features in products. A knowledge base is used to compute the relevance between a specific colour and a set of impression concepts, such as "sharp" and "cool", by using a dictionary that defines abstract semantics of colours [24][25]. A colour-impression association knowledge base provides a matrix (colour impression definition matrix; CID matrix) that defines colour features of colour schemas related to 130 colour variations (Figure 1). Each colour schema corresponds to a specific impression in human's perception [26]. In [25], the colour-impression space has been created, using 120 chromatic colours and 10 monochrome colours defined in the "Colour Image Scale" [27], which is based on the Munsell colour system [28], as shown in Figure 2. Figure 1 shows several examples of the colour-emotions defined in "Colour Image Scale" [27]. The colour-emotions are expressed in 120 chromatic colours and 10 monochrome colours which are based on the Munsell colour system. Each colour schema, which corresponds to a specific emotional perception of humans, is described by using a combination of several colours from the 130 basic colour set. Each colour-emotion, such as vivid(cs2) and sweet(cs5), defines colour features in 182 sets of colour schema related to 130 colour variations. Each colour schema corresponds to a specific emotion in human's perception.

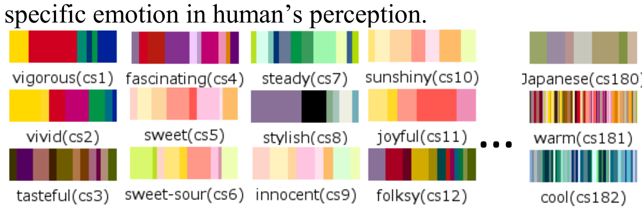

Figure 1. Colour-impression association for defining colour features in 182 sets of colour schema related to 130 colour variations defined in "Colour Image Scale" [27]. Each colour-impression definition, such as "vigorous (cs1)" defines a set of weight for colours

Figure 2. 130 Munsell Basic Colour Variations defined in "Colour Image Scale" [27].

The system converts RGB colour values to HSV colour values per pixel of each image. HSV is a widely adopted space in image and video retrieval because it describes perceptual and scalable colour relationships. The system clusters HSV pixels into the closest colour of the predefined 130 Munsell basic colours [1], and calculates the percentage of each colour to all pixels of the image. And then the system creates 130 HSV colour histogram. The image metadata generation function *fimage_metadata(D)* is defined as follows:

$$f_{image\_metadata}(D) \rightarrow I := \{i_{[0]}, \cdots, i_{[129]}\}$$

where D denotes an image data, and $i_{[n]}$ denotes a *i*-th colour feature value. The method analyzes images to generate a colour-impression based metadata vector. The method extracts the colour-impression features of the image and

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inserts them into the metadata cache database. The system analyzes the colour-impression features by performing the following four steps as described in Figure 3:

- (**Step-1)** The system decodes an input image file such as JPEG and PNG.
- (**Step-2)** The system converts RGB colour values to HSV colour values per pixel of each image. HSV is a widely adopted space in image and video retrieval because it describes perceptual and scalable colour relationships.
- (**Step-3)** The system clusters HSV pixels into the closest colour of the predefined 130 Munsell basic colours[1], and calculates the percentage of each colour to all pixels of the image. And then the system creates 130 HSV colour histogram.
- (**Step-4)** The system extracts the colour-impression for the image by correlation calculations between 182 colour schemas (182 impression word sets) and 130 basic HSV colours.

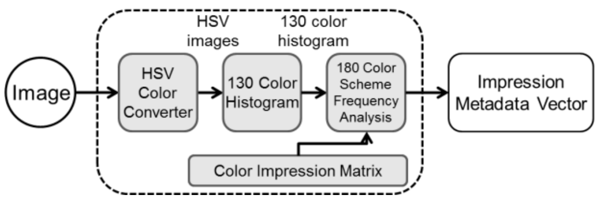


Figure 3. The process of colour-impression based metadata extraction [24][25].

III. Architectural Framework of the Personalized Recommender System Model Using Colour-Impression-Based Image Retrieval and Ranking Method

Figure 4 illustrates the architectural framework overview of our personalized recommender system model. It is based on service-oriented architecture (SOA) due to several important SOA characteristics, especially flexibility and reuse. These allow for easier adaptations of the model to different environments. To address the service orchestration principles of SOA [34][35][36][37], the key business process of the online shopping domain (i.e., the Online purchase process), is implemented with the Web Service Business Process Execution Language (BPEL) [38].

A high level overview of the process and its main subprocesses is given in Figure 4 using the standard Business Process Model and Notation 2.0 (BPMN) [39]. The recommender model concerns its Product search and selection subprocess, as shown in Figure 5. It is important to note that the model is generic and that the proposed SOA framework allows that BPEL processes are extended with existing recommender system services. Figure 6 demonstrates the BPMN model of the Product search and selection subprocess and how the architectural components relate with the colour-impression-based image retrieval and ranking method.

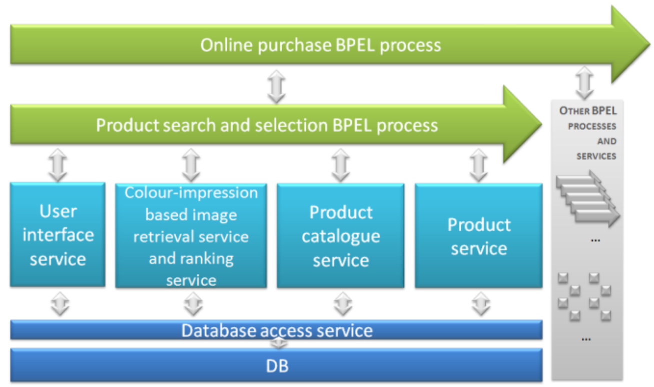


Figure 4. Architectural framework overview

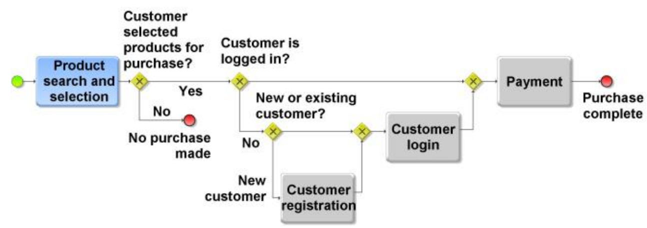


Figure 5. Online purchase process overview

Swimlanes are used to show which services are invoked by the BPEL process for execution of the corresponding process tasks and which tasks are performed by the user. For clarity and understanding of our work, the process models do not show details that are irrelevant for the research presented in this paper. One can observe that the model is based on interactivity with the user and that the presentation of the products to the user is updated for every main user action (*interactivity loop*). There are three main types of user activities when searching for desired products:

- The customer may select impression words appertaining to the desired products. In this case the colour-impression-based image retrieval and ranking function returns products that are the most relevant for the given impression words based on the product images. The presentation of the products for the customer changes and shows the resulting products.
- The customer may select a product, for example to see more details about it. In this case, the colour-impression-based image retrieval and ranking is performed based on the images of the selected product. Products with similar-impression images are returned and are presented to the customer in the side frame.
- The model also allows for the standard product attribute selection, such as type of the product, colour, size, material etc. In case the customer changes the attributes and if the customer has already chosen the impression words, products are first filtered in order to retrieve the products that correspond to the selected attributes. Then the colour-impression-based image retrieval and ranking function performs the search based on the filtered product images. The presentation of the products for the customer changes and the resulting products are shown.

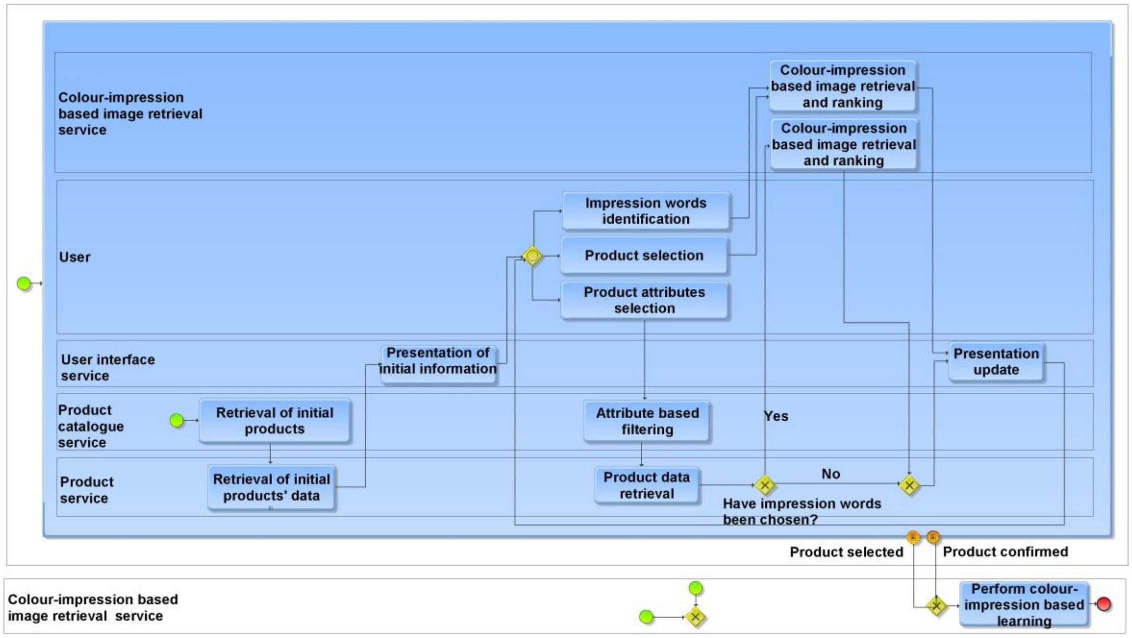


Figure 6. Product search and selection process overview

The colour-impression-based image retrieval and ranking function is integrated in all interactivity loops. However, the process differs if the customer is logged or not. If the customer is logged in, their personal CID matrix is used. Otherwise, the common domain CID matrix is used as the basis.

Colour-impression-based learning is performed every time a user selects the product and every time the user confirms a product for purchase. Based on the impression words specified by the customer and the selected/confirmed products, product image analysis is performed to obtain the colour features of the images. The corresponding CID matrix is adjusted in order to give a stronger association between the impression words and selected product images. If the customer is not logged in and the common domain CID matrix is used, the adjustments are performed on a copy of the common domain CID matrix. If the customer later logs in, the adjustment is applied to the adjusted CID matrix. Thus the CID matrix implements the personalization based for specific customers. Otherwise, the matrix is used only during the customer session.

IV. EXPERIMENTAL STUDY

We have performed an experimental study of the model for the decorative photography domain. The corresponding online purchase business process was implemented based on the architectural framework discussed in the previous section. For the use cases examples presented in the remainder of this section, the selected product attributes were: category: scenery, landscapes, places; size: 4:3 and 16:9. 205 images corresponded to this attribute selection. Table I demonstrates photograph images of three result sets of the colour-impression-based image retrieval and ranking: first for the impression word "earnest", second for the word "exact", and third for the words "earnest, exact". The impression word query "earnest, exact" returns those images that are semantically the closest to both impression words. Correlation values are given for the resulting product images.

TABLE I. PRODUCT IMAGES PRESENTED TO THE CUSTOMER BASED ON AN AJUSTED CID MATRIX AND THREE EXAMPLE IMPRESSION WORD SETS

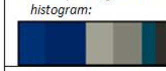
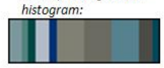
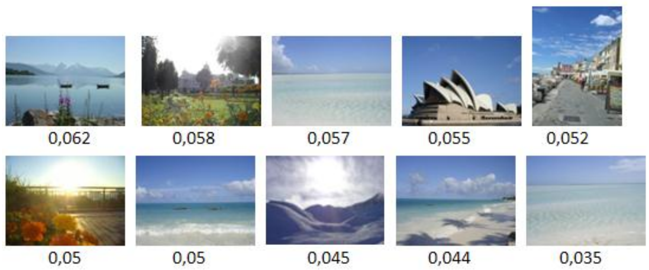
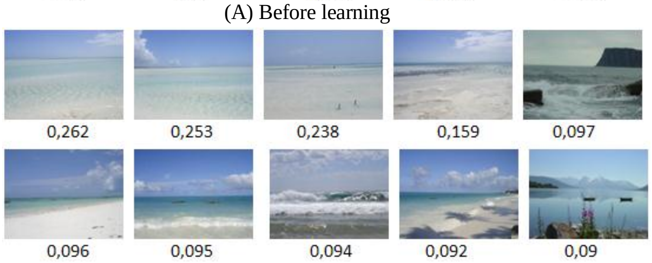
Impression words	Five resulting images with the highest correlation values
Earnest *Corresponding colour histogram:* 	 0,113 0,081 0,070 0,066
Exact *Corresponding colour histogram:* 	 0,085 0,083 0,077 0,076
Earnest, exact	 0,129 0,129 0,121 0,118

Table II demonstrates two image result sets for the impression word "crystalline". Table II (A) represents the results based on the common domain CID matrix. Let us consider the example where after the customer is presented with the resulting 10 photographs. The customer then selects the product with the last image in the result set (image with the correlation 0,035 in Table II (A)). When the product is selected, colour-impression-based learning is performed. Besides the product details for this photograph, the customer is presented the image result set of the Table II (B) without the first photograph (as it is the same as the selected photograph). One can easily notice the difference in the results and the adaptation to the customer's perceptions. Furthermore, next time the customer performs the search for the word "crystalline", the resulting photographs would be refined and adjusted to the customer. For the same input set of images the result would be as presented by Table II (B).

TABLE II. EXAMPLE IMAGE RESULT SETS FOR THE IMPRESSION WORD "CRYSTALLINE"



(A) Before learning



(B) After learning

V. CONCLUSION AND FUTURE WORK

This paper has presented a recommender system model based on the colour-impression-based image retrieval and ranking method in [24][25]. This paper has demonstrated how the colour-impression-based image retrieval and ranking method can be applied to recommender systems for online shopping. The method is based on extraction of colour-impression features from images based on images' colour features. The presented model is very useful, especially for domains where colour-based impressions play an important role in customer decisions for product selection and purchase, for example fashion and decoration domains. It is based on service-oriented architecture for greater flexibility and easier adaptation to different environments.

Other important multimedia and image analysis methods exist that can be applied to recommender systems, such as [40][41]. In our further work we shall extend the model with some of these methods in order to improve the model and extend the target domains by taking into consideration other information carried by images, such as combination of colour, shape and structure features, and other types of multimedia, such as video and sound.

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