Recommendation System for Automatic Design of Magazine Covers

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ABSTRACT
In this paper, we present a recommendation system for the automatic design of magazine covers. Our users are non-designer designers: individuals or small and medium businesses who want to design without hiring a professional designer while still wanting to create aesthetically compelling designs. Because a design should have a purpose, we suggest a number of semantic features to the user, e.g., "clean and clear," "dynamic and active," or "formal," to describe the color mood for the purpose of his/her design. Based on these high level features and a number of low level features, such as the complexity of the visual balance in a photo, our system selects the best photos from the user's album for his/her design. Our system then generates several alternative designs that can be rated by the user. Consequently, our system generates future designs based on the user's style. In this fashion, our system personalizes the designs of a user based on his/her preferences.

Author Keywords
Visual design principles; aesthetics; layout; visual balance; color design; autonomous; recommendation; personalization

ACM Classification Keywords
H.5.2 Information Interfaces and Presentation: User Interfaces

H.1.2 Models and Principles User/Machine Systems - human factors, software psychology

General Terms
Human Factors; Design; Theory.

INTRODUCTION
In the information era, the representation of information via visual media is a desire for both personal and business means, though these consumers may prefer not to hire a professional to create designs for them. Personal communication through internet web services is becoming an essential part of contemporary life. New generations of communication devices also contribute to a need for the design of personal communication media. Hence, there is a great need and an increasing request for software applications that provide users with easy-to-follow steps for creating visual media, such as magazines, blogs, and other forms of self-publishing media. This need, in turn, inspires science and engineering to tackle the idea of visual media's automatic design.

An automatic design system, however, needs to take into account the key concepts of design and address the challenges that designers encounter when creating a design. The key concepts include: elements of design, principles in design, and aesthetics of design. By elements of design, we mean layout and visual balance considerations, typography, design of color, style, and context. Principles in design, however, refer to a number of rules that a designer may apply to accomplish the task of design. Aesthetics of design deals with the beauty of designs and how good a design is, considering both the form and function of a design. In fact, an automatic design system has to quantify these subjective concepts. Moreover, such a system has to perform the task of design automatically and autonomously. From a broader perspective, this system should be able to recommend to the user a number of designs and to customize the future designs for a user based on his/her personal preferences. Therefore, designing effective sets of interactions for user participation in the process of automatic design of visual media based on his/her preferences is required.

In this paper, we introduce a recommendation system for automatic design of magazine covers. Professional designers start a design by developing a concept to convey the message or purpose of the design. Similarly, our system guides the user to understand the purpose of his/her design. The purpose of a magazine cover design relates to the context of its cover image [11]. The context of the cover image has several aspects, including the color mood and the objects. At this stage, we focus on the color mood: we recommend a set of semantic descriptors to the user to understand his/her preferred color mood in his/her design. The system then selects

IUI'13, March 19–22, 2013, Santa Monica, CA, USA.

a number of photos from the user's album based on his/her preferences and generates alternative designs.

We focus on magazine covers as an application of the idea of automatic design, especially because of the need for self-publishing designs in recent years. This need has also been addressed in prior work, such as [6] and [25]. There are now several tools and services for design of magazine covers. As an example, HP MagCloud websites [4] provide individuals as well as businesses the ability to design and upload magazine covers to share with others. Moreover, there are several on-line tools and apps for magazine cover design for amateurs, which is in contrast with tools that facilitate professionals for the design of magazine covers. Consequently, some well-known magazines such as Wired and Cosmopolitan have started offering design of personalized magazine cover as promotions to customers. As an example of other applications of our work, consider the case for providing non-designer designers with the opportunity to design magazine-like documents to communicate with specific target audiences. For instance, Greig et al. [14] suggests a system which creates a travel brochure, but it has to be enhanced by adding features that recognize how to design an effective cover. Other potential users include small non-profit organizations that need to design magazine covers and other magazine-like documents to generate excitement and credibility about their work, without hiring professional designers [6]. Furthermore, as we suggest in the discussion section, our work could be considered as a starting point to contribute to the idea of creativity support tools for both non-designer and designer users.

Our recommendation system is an extension of the automatic design system ADoMC, or Automatic Design of Magazine Covers, by Jahanian et al. [21]. Hence, we call our recommendation system R-ADoMC. Although we dedicate one section to ADoMC, we describe each part of R-ADoMC, including: Input User Interface, which suggests different purposes of a design to the user; Evaluation of Input Photos, which deals with the user's inputs; Designs User Interface, which provides a rating mechanism of the generated designs for the user; and Personalization of Designs, which recommends more designs based on the preferences of the user. We finally discuss the current limitations, challenges, and the future work. In the next section, we illustrate a common scenario that typically occurs with our users.

SCENARIO

Our users are non-designer designers, individuals and businesses who want to design without hiring a professional designer, while still wanting to create aesthetically compelling designs. Consider the following scenario: John has a pile of photos, and he wants to make a magazine cover with the best photo from the group. John also has a number of stories as his cover lines that he wants to place on the cover. He has thought about the priorities of his stories in terms of their importance. He knows what he would like to call his magazine title, but he may or may not have a predesigned masthead for his magazine title. John wants to make an attractive design, but he has no idea about the principles of design. The only thing that he knows is that he wants a "sporty and dynamic" design. Designers believe that if someone does not know how to design, he/she can easily make non-pleasing designs [20]. They also believe that any changes made in a design would lead to a different design, and the designer would have to start a new design from scratch. From the above input, R-ADoMC is implemented to create a design from start to finish. It does not allow any modifications on the user's part. Instead, it provides a number of designs to the user and lets him/her choose one. It also recommends a design based on the preference of the user. In John's case, R-ADoMC takes his photos and stories (i.e. cover lines), and then it suggests a number of adjectives to him that describe some possible kinds of design, e.g., "clean and clear", "dynamic and active", "elegant", "formal", etc. In the next sections, we discuss these adjectives, their origins, and the way that we deploy them to create a design.

RELATED WORK

We believe the work of visual media's automatic design, magazine covers in particular, is a multidisciplinary task that spans several different topics, including automated layout, color design, typography, computational aesthetics, and recommendation with personalization. The following subsections review the related work in each area and how we apply or extend the prior work.

Automated Layout

Automated layout – how to position the textual and graphical elements in the format of documents including newspapers and magazines – has been an active area of research activity. Lok et al. [28] and Hurst et al. [18] provide surveys of automated document layout techniques. Most of the related work is based on the concept of grids in design. We also use the idea of making and breaking grids, comprehensively discussed in [33]. The idea of automated layout has recently been used in design of photo-books [42], web-based magazines [17], and semi-automated magazine layout [25]. The main difference between the prior work and our work is perhaps the fact that we apply the layout onto a bitmap, or an image, as the background, or the canvas, rather than a white space. This requires dealing with the composition and complexity of the images, as well. In fact, our definition of white space is different, since we consider the non-salient part of an image as the white space. In this paper, we will describe how we find the salient and non-salient parts of an image, and how we use them to convey visual balance in a layout.

Color Design

Color design is a broad concept in design that ties with several well-known color models proposed by color theorists. In computer science and engineering, researchers have deployed some of these color theories, such as color harmony and complementary colors. [41] uses Matsuda's harmonious hue and tone templates as well as Kobayashi's color image scale to support users for the selection of colors for product design. [9] also uses Matsuda's harmonious templates for color harmonization in images. [31] studies color preferences provided from two color design websites Adobe Kuler [1] and COLOURLovers [3]. In our work, however, we use the well-known color theories of Itten [19], Matsuda [41], and

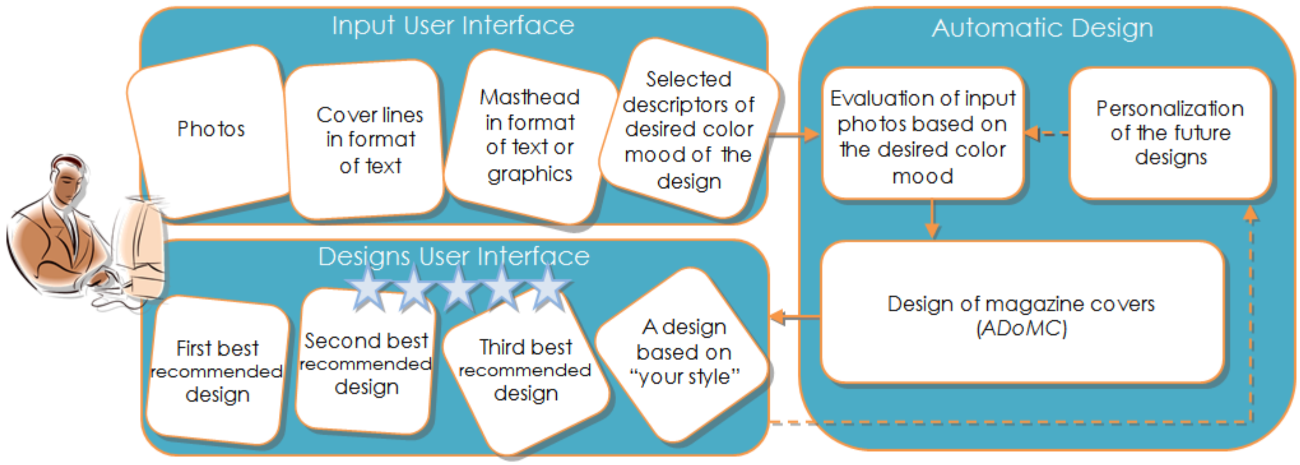


Figure 1: A schematic view of R-ADoMC. The user uploads his/her photos, cover lines, and masthead. Then, he/she chooses some recommended descriptors to indicate the desired color mood of his/her design. R-ADoMC evaluates the user's photos and chooses the best. It then sends the selected photos to the design engine. The generated designs will be shown to the user, who can rate the generated designs. The ratings will be considered for the user's future designs to recommend him/her one more design based on his/her style.

Kobayashi [32] to evaluate input cover images and to automatically choose colors for the cover lines of a magazine cover.

Typography

Typography in automatic layout is often considered as an optimization problem [18]. Knuth's work [23] is perhaps the most effective solution for typography. Recently, [27] suggests an algorithm based on Knuth's work for text fitting in arbitrary geometrical regions for digital publishing. The automatic text insertion in our typography is inspired by both [23] and [27], while dealing with text fitting in geometrical regions. Typography in design also deals with the aesthetics of typefaces and which typeface to choose for the purpose of a design [34]. Although we alternate the typeface of the textual elements in design of a magazine cover, choosing a good typeface for the purpose of a design is mentioned in the Discussion section as our future work.

Computational Aesthetics

Quantifying aesthetics of images is another trend of research. Birkhoff's [8] model is perhaps the first mathematical expression for aesthetics. [30] deploys Birkhoff's model for measuring aesthetics of layout of user interfaces on the screen. From another perspective, [13] develops a genetic algorithm for computing aesthetics of photo-albums. Datta et al. [10] applies a number of machine learning techniques in computational aesthetics of photos. However, machine learning techniques require defining effective features to quantify aesthetics and should be considered based on both function and form. That is why in our work aesthetics considerations are part of each module of design, e.g., aesthetics of color design or visual balance as well as the final design. Moreover, unlike other methods, we consider high level or semantic features (e.g. "clean and clear" colors) rather than just low level features (e.g. lightness of color). From a psychological viewpoint, [26] suggests an exploratory factor analysis for this purpose and lists a number of semantic terms in aesthetics of design. However, to the best of our knowledge, deployment of high level features in automatic design has not been considered in previous work. This is, in fact, part of this paper's contribution.

Recommendation Systems

Recommending a generated design from scratch for the user is another contribution of this paper. [16] discusses how designers can benefit from examples recommended by a recommending system to support their creativity in new designs. The main difference, however, is that in our work we create designs and recommend them to non-designer users. In recommendation systems, typically, prediction of a user's preferences is based on a rating data set, accumulated from the same user and similar users [5]. In our work, we personalize the future designs for a user by predicting his/her personal preferences in design and by inferring a style for him/her based on his/her ratings.

SOFTWARE FRAMEWORK

This section describes how we think about the problem of automatic design from the viewpoint of software engineering and computer science. We endeavor to quantify the elements and concepts in design and bring these subjective topics to the realm of objection. Our approach includes close collaboration with professional designers, magazine art directors and editorial boards, and journalists. The current software framework is the projection of a number of rules, mathematical expressions, and algorithms delineated and devised from the lessons we have learned so far. The following sub-sections describe each part of the system in more detail. We first start by looking at a schematic view of the framework and the relation of each part with others.

Schematic View

As Figure 1 illustrates, the system is comprised of three major parts: Input User Interface, Automatic Design Engine, and

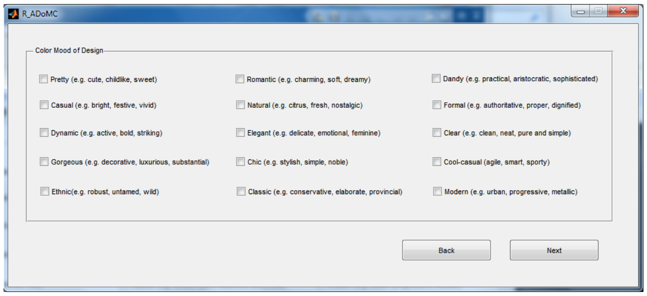


Figure 2: Descriptors for color mood of design. The user can tell R-ADoMC which color mood he/she wishes to convey in his/her design. These descriptors are suggested by [32] to relate the world of colors to the world of styles and human preferences.

Designs User Interface. The system first takes the user's inputs, which includes a collection of his/her photos, a number of text strings as his/her magazine cover stories (e.g. headline and byline), a masthead for the title in the format of a text string or a predefined logo, and a number of predefined adjectives describing the desired color mood of his/her design. The system then evaluates the user's photos based on his/her chosen adjectives. In this way, the system can order the input photos based on their aesthetics, including both form and functional aspects. The best photos are then sent to the design engine. This engine is called ADoMC and is based on work by Jahanian et al. [21]. The designs generated by ADoMC, which in turn pass a visual composition criterion, are presented as the final designs to the user by listing them in order of best design. The user can rate the generated designs using a five-star rating scale. The system incorporates the user's ratings in the personalization part to customize his/her future designs. In this fashion, the system will suggest to the user one more design among the other designs that he/she may like by indicating that it is based on "your style."

Input User Interface

A magazine cover has a main photo called a cover image, a title called a masthead, and a number of stories, including headline, byline, and other cover lines [11]. The user can upload his/her cover image, masthead, and cover lines to R-ADoMC. Users generally have a number of photos and may wonder which photo could be a good candidate for a magazine cover. On the other hand, since the context of the cover image influences the purpose of a magazine cover design, we recommend a list of adjectives to the user to describe several color moods in the context of a magazine cover. Although the context of a photo includes aspects other than color, at this stage of our work, we address only the color aspect. After the user chooses a set of adjectives, or color mood descriptors, R-ADoMC can evaluate the user's photos, rate them, and generate alternative designs. Figure 2 illustrates the menu of the color mood descriptors in R-ADoMC.

Evaluation of Input Photos

Computational aesthetics of photos is one of the recent interests in computer science and engineering. However, most of the related work is focused on a number of low level features in a photo, such as color distribution, texture, and objects [22]. These features are part of the aesthetics of photos, but they are context-free. Since a design has a mission and conveys a purpose to the audience, we also need a set of high level features to be able to describe a design and its color mood. Our solution to this challenge is inspired by the work on the Color Image Scale by Kobayashi [32]. Kobayashi has proposed a semantic view to the aesthetics of colors to relate the world of colors to the world of objects, life styles, and human preferences. Therefore, we use his work to quantify the mood of our designs from a semantic viewpoint. Kobayashi's Color Image Scale is an attempt to investigate the meanings that people may perceive from the colors and color combinations, from a number of psychological, systematic, and pragmatic approaches. This viewpoint comes from the idea of associating the physical attributes of the colors – hue, value, and chroma — to a higher level of abstract attributes of colors – warm-cool and soft-hard. Kobayashi and his institute, Nippon Color and Design Research, have conducted more than a decade of psychophysical experiments on colors. They asked individuals and groups of people to match a color and a combination of three colors with an adjective. Through factor analysis, a semantic differential method, and cluster analysis, Kobayashi came up with a list of adjectives as color descriptors or "color-images." Kobayashi then applied his scale to different color designs, for example, clothes, food, and several other industrial design applications [24]. Kobayashi later published his Color Image Scale in a book with the same name [32]. Today a Japanese website uses his work in a search engine for images [2]. Recently [37] has deployed Kobayashi's scale for image retrieval. We deploy the mathematical framework that [37] develops to implement Kobayashi's color scale for the purpose of image retrieval; hence, we use almost the same notation. We, however, use this framework to measure and evaluate the input photos for the purpose of a design. Kobayashi first defines 130 Basic Colors. He then defines 1170 3-Color Combinations and associates them with 180 adjectives (called color-images) or Labels. Each 3-Color Combination is also associated with a five-star rating that indicates the frequency of its usage. The Labels are later classified into 15 Patterns. The Patterns represent a number of selected terms in fashion and lifestyle. Kobayashi positions his 3-Color Combinations on a scale of warm-cool and soft-hard, and based on this arrangement, defines the boundaries of each Pattern. Figure 3 illustrates Kobayashi's Color Image Scale with the 15 Patterns and some of his 3-Color Combinations.

Our problem is how to locate a given image on Kobayashi's Color Image Scale. First we need to find a way to represent an image in sRGB color space in terms of Kobayashi's 130 Basic Colors. One way is to represent the image by its histogram. In other words, the problem is: how to convert the sRGB histogram of an image to its corresponding histogram in Kobayashi's 130 Basic Colors. To do so, we quantize the sRGB color space to a smaller space with 8 levels of R, 8 levels of G, and 8 levels of B. This leads to 512 sRGB colors, or bins. We obtain the Kobayashi's histogram of an image, denoted by h_K from the sRGB histogram of the image, denoted

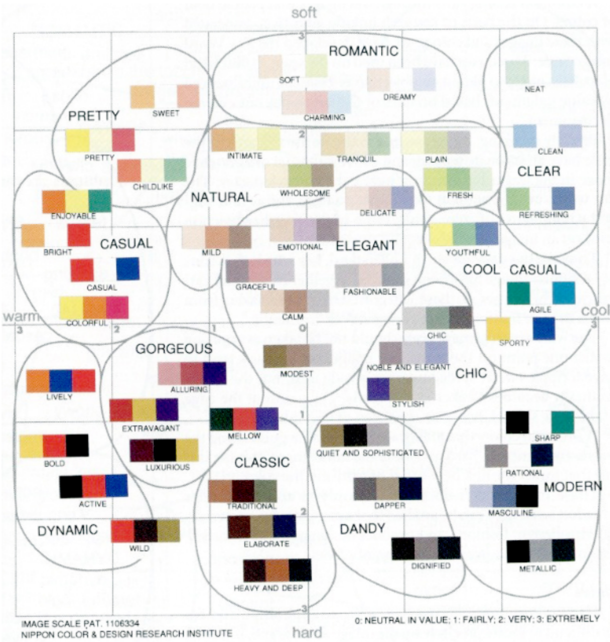


Figure 3: Kobayashi's Color Image Scale. Image taken from [32]. The contours show 15 patterns, labeled by all-capital letters. We use these patterns to describe the desired color mood of the design.

by h_{RGB}, according to the following Equation:

$$h_K = h_{RGB} \cdot T \tag{1}$$

Here T is the transformation matrix. We construct T by first converting both the quantized sRGB space and the 130 Basic Colors to CIELab color space. This space is perceptually uniform, and so we measure the distance between each pair of colors converted from these two color spaces in terms of their Euclidean distance in CIELab, denoted by $\triangle E_r$. We can then define the elements of the transformation matrix T:

$$t_{rl} = \begin{cases} 1 - \frac{\triangle E_r}{10} + 0.1 & \text{if } \triangle E_r \leq 10 \\ 0 & \text{otherwise} \end{cases} \tag{2}$$

where $r = 1, ..., 512$, and $l = 1, ..., 130$.

Hence, we obtain Kobayashi's histogram h_K of an image. The next step is computation of the distribution of any 3-Color Combination in the given image from its corresponding h_K. To do so, we first define the following notation to refer to a 3-Color Combination:

$$c_n^{(3)} = \{b_n^1, b_n^2, b_n^3\} \tag{3}$$

where $0 \leq b_n^i \leq 130$ denotes the index of a Basic Color.

Now we define h_σ as the distribution of the all 3-Color Combinations in a given image by:

$$h_\sigma = [\sigma_1, ..., \sigma_{1170}]^T \tag{4}$$

where

$$\sigma = \min(h_K(b_n^1), h_K(b_n^2), h_K(b_n^3)) \tag{5}$$

for $n = 1, ..., 1170$.

Next, we define matrix L as an index matrix to associate the 180 Labels to the 1170 3-Color Combinations:

$$L = \left[\vec{l_1} \dots \vec{l_{180}}\right] \tag{6}$$

where L is a 1170×180 matrix and

$$l_{ij} = \begin{cases} 1 & \text{if label } j \text{ is associated to Color Combination } i \\ 0 & \text{otherwise} \end{cases} \tag{7}$$

Also, we define the diagonal matrix R, which contains the ratings of each 3-Color Combination. Hence, we obtain the distribution of each Label in an image by h_L as:

$$h_L = h_\sigma \cdot R \cdot L \tag{8}$$

Similar to Equations 6 and 7, we can define the matrix U as an index matrix to associate the 15 Patterns to the 180 Labels. Hence, we obtain the distribution of each Pattern in an image as follows:

$$P = h_L \cdot U \tag{9}$$

Finally, given the location of all the 180 Labels on the scale from the matrix E, we can obtain s, the location of the given image on the scale from:

$$s = h_L \cdot E^T \tag{10}$$

As an example, Figure 4 illustrates the location of an image on the Color Image Scale. In fact, we can find which of the Patterns, or in our word, color moods an image holds. The normalized values of matrix P give us a measure of closeness or similarity of an image to each Pattern. We use this measure to rate the user's photos and compute the best matches to Patterns. As we mentioned, this method deals with the high level features of an image's aesthetics. However, we also consider a low level feature in images, which is the layout composition of the image. We suggest this feature because the composition of the cover image heavily influences the visual balance and layout of the design of a magazine cover. Therefore, if an image maintains a busy composition, it will not be included among the final designs. At this stage, we equate the layout composition of an image with its visual saliency and compute it with the Graph-Based Visual Saliency algorithm [15].

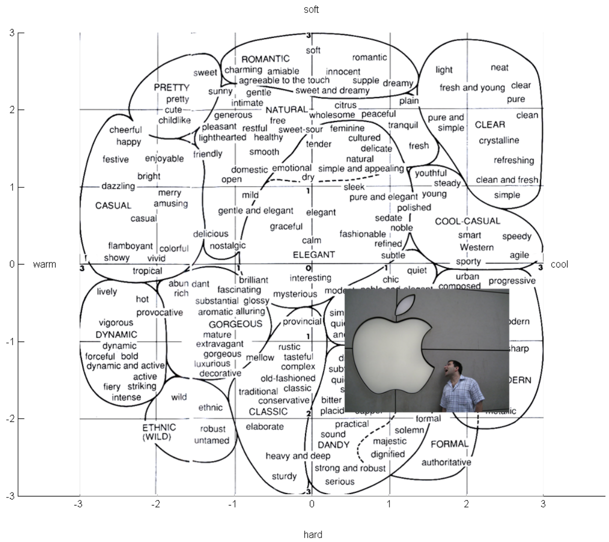


Figure 4: The location of an image on Kobayashi's Color Image Scale. This image is considered to be CHIC and MODERN according to this scale. The scale is taken from [32].

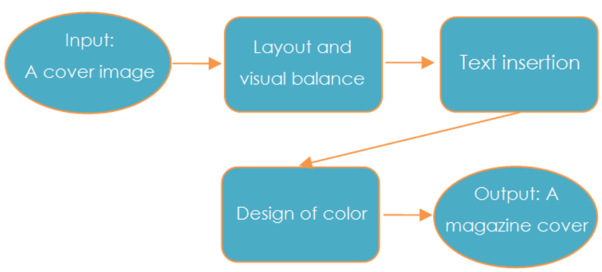


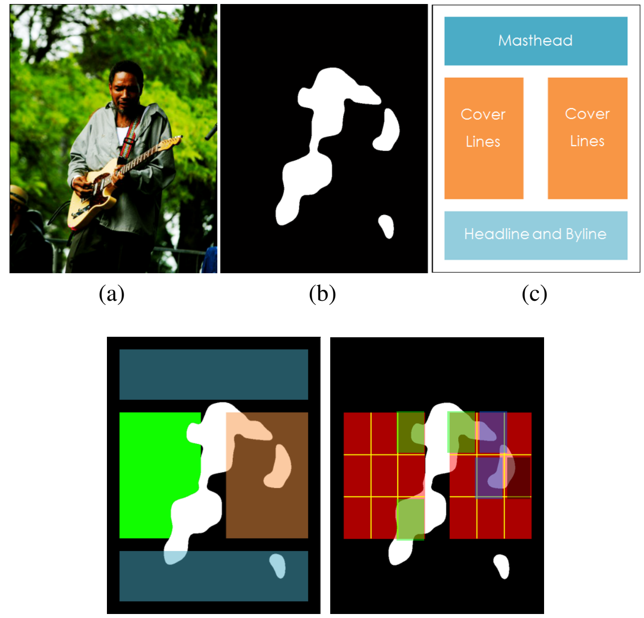
Figure 5: A schematic view of ADoMC. Image reproduced from [21].

Design Engine

After having a cover image selected by our evaluation mechanism, the next action is to design a magazine cover with it. This section is an overview to the automatic design of magazine covers (ADoMC) system [21]. A design process typically includes three modules: layout, typography, and design of color. Similarly, ADoMC quantifies and implements these modules. Figure 5 illustrates a schematic view of ADoMC.

Layout

As noted in [28], layout can be considered as a process that tries to solve the problem of positioning the visual elements while considering or determining their sizes. However, creating aesthetically pleasing layouts ties with visual balance considerations in design. Visual balance for designers means holding the property of "looking right" in a layout and can be considered as "visual weight" [29]. This term, the work of [30] in measuring aesthetics of layout, and the grid-based approach in layout [33], form the quantification approach of the visual balance of magazine cover layout in ADoMC, illustrated in Figure 6. In design, the form of the layout should follow the functionality of the design. For instance, the layout

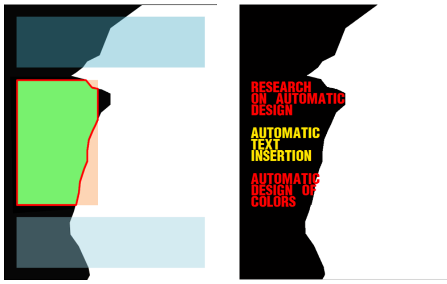


(a) (b) (c)

(d) (e)

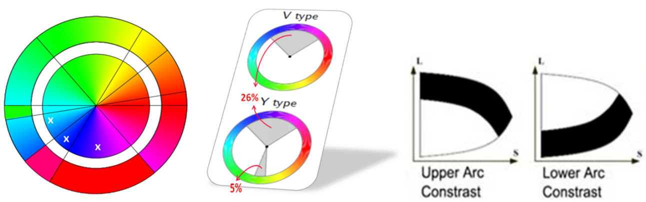
Figure 6: Layout decisions and visual balance considerations. a) An image. b) GBVS [15] binary mask. c) a general template for magazine covers. d) Fusion of general cover template (Figure 6.c) and GBVS binary mask (Figure 6.d). ADoMC [21] keeps the green region and discards the brown region, since the green region looks empty and is a good candidate to hold the cover lines. This decision is made by computing the visual balance as shown in part e (Figure 6.e). e) Computation of visual balance: different weights are assigned to the cells of the yellow grids on the left and right sides of the cover image: the darker the cells, the heavier the weights. Summing the product of each cell's weight and the number of salient pixels (white, here) gives us the weights of the left and right grids. The side with a lighter weight will be considered as an empty space to hold more elements, such as the texts of the cover lines. Images reproduced from [21].

of the magazine cover should be in a form that directs the eyes of the audience through the design [11]. Based on the advice of designers, ADoMC applies a general template for magazine cover layout (illustrated in Figure 6.c). This template, however, can be reformed based on the visual balance of the cover image. For visual balance considerations, ADoMC first finds the white spaces of the cover image. Here, white space on the background image means the regions of the image which are less busy relative to the other regions of the image. That is, ADoMC finds the non-salient segments of the image by deployment of the Graph-Based Visual Saliency algorithm (GBVS) [15]. ADoMC then fuses the binary GBVS mask with the general magazine cover template. The result yields the candidate regions for holding the textual elements on the cover. Finally, ADoMC applies grids on the image and assigns different weights to different cells of the grids to compute which candidate region should hold the textual elements. In this fashion, ADoMC conveys the visual balance in the layout of magazine covers.



(a) (b)

Figure 7: Typography of cover lines for a magazine cover. a) Given the green region computed from Figure 6 as a candidate to hold cover lines, ADoMC [21] fits the text of the cover lines in it. It applies a form of text indentation to follow the boundaries of the green region. However, this process is performed in a way such that the size of the text is as large as possible for the purpose of legibility. b) Result of the automatic text fitting in the green region in (a). Images reproduced from [21].



(a) (b) (c)

Figure 8: Color Design for masthead and cover lines. a) ADoMC [21] incorporates this complementary color wheel based on a continuous version of Itten's hue wheel. The crossed region inside the inner disc is discarded and replaced with the corresponding sectors in the outer ring. b) ADoMC uses these two templates of Matsuda's hue templates. The colors in the shaded sectors are considered to be in harmony. c) ADoMC uses these two templates of Matsuda's tone templates. The colors in the black arcs are considered to be in harmony. Images of (b) and (c) are reproduced from [9].

Typography

Where and how to put text, including the masthead, headline, byline, and other cover lines, is an important decision in design of magazine covers [11]. In our problem scope, by typography we mean the decisions that a designer makes about using different typefaces for different design purposes, the text size of the cover lines, priorities of the cover lines, and the problem of legibility of the text. According to professionals, the family of *Helvetica* is a good choice for a typical magazine cover. Better choices, however, relate to the class of magazine and will be considered in our future work. Similar to the preceding discussion for layout, we need to convey the priority and the hierarchy of the cover lines on the cover. Therefore, ADoMC assigns different sizes to the cover lines and lays them out based on their priority (specified by the user) starting from the top of the cover. Given a candidate region from the layout process, ADoMC inserts the text by applying a special form of indentation. This indentation is a pattern derived from well-known magazine designs. That is, designers usually give an indentation to the texts to align them with the boundaries of the salient segments of the cover image. This technique can be formulated as how to insert or fit a text in a geometrical region such that its indentation is most faithful to the shape of the region. ADoMC solves this problem as an optimization problem in which the maximum fidelity to the shape of the geometrical region and the maximum size of the text is desirable. Figure 7 illustrates the results of this solution for different numbers of cover lines with different words.

Color

Design of color for textual and graphical elements on a magazine cover is another challenge for magazine art directors [11]. In the automatic process of color design, one needs to address both aesthetics and legibility of the color text. In order to tackle the aesthetics of colors, ADoMC draws upon the well-known theories of color harmony. One of the most significant works in the area of quantifying aesthetics of colors is Itten's color harmony concept [19]. Itten defines seven kinds of color contrast: contrast of hue, light-dark contrast, cold-warm contrast, complementary contrast, simultaneous contrast, contrast of saturation, and contrast of extension. Among these contrasts, ADoMC applies the concept of complementary contrast to choose the color of the masthead. For the color of cover lines, ADoMC then uses Matsuda's hue templates [41] and [9], which are perhaps an extension of Itten's color harmony. The problem of illegible text may occur when the hue or the tone of the text in the foreground competes with the hue or the tone of its local background. Hence, for legibility of the text, Matsuda's tone templates are deployed as well as the hue templates. Figure 8.a illustrates how ADoMC customizes a continuous version of Itten's hue wheel. Figures 8.b and 8.c also illustrate the four (among eighteen) of Matsuda's hue and tone templates that are used. The reason for this choice is that these templates are more likely to occur in the contemporary context of well-known magazine cover designs, as analyzed and suggested by professional designers [20].

Designs User Interface

Getting the user to effectively visualize the results is a challenge when designing a user interface for recommendation systems. This, in turn, influences the personalization of the user's results. In our problem, we aim to present more than one design to the user in order to understand his/her design's purpose and to customize his/her future designs. We believe this is an added value for non-designers because it provides them designs that are aligned with their personal preferences and styles. In this fashion, we devise an interactive process between the automatic system and the user while creating a design, which also happens in practice between a professional designer and his/her client. Figure 9 illustrates R-ADoMC's user interface. R-ADoMC displays the first choice design in the main GUI and arranges two more design choices, along with a design based on the user's accumulated ratings in a separate panel. It also provides a five-star rating scale option by the user for these designs [38] provides a number of guidelines for choosing a rating scale, the options being unary ("like it"), binary (thumbs up/thumbs down), five-star, or a

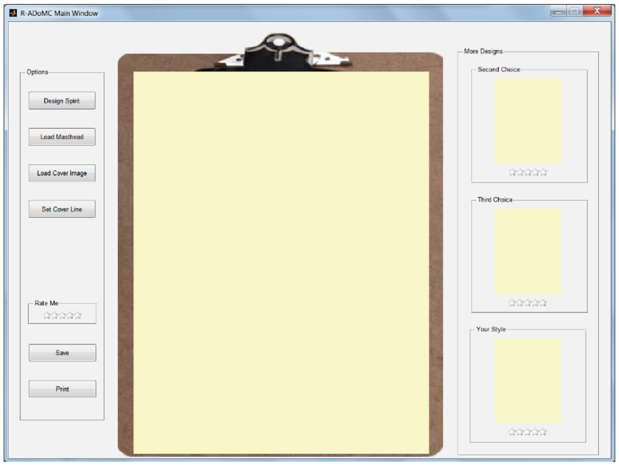


Figure 9: Designs UI for visualization of the designs generated in R-ADoMC. A rating option is available for each design, and the ratings will be considered in the user's future designs. The "your style" design is a representation of the idea of personalized designs for the user. The more that the user works with the system, the more that the system is able to personalize the future designs.

100-point slider. The degree of accuracy and user friendliness of the five-star method is a good choice for our work. In this way, we accumulate a better understanding of what kind of design the user likes, and consequently, we can customize his/her future designs.

Personalization of Designs

Is it legitimate to personalize designs? Although form follows function – or the context of a design should be aligned with the mission of the design – it can also be personalized. In fact, one way of thinking about personalization of a design is to think about the design's style, which comes from the preferences of a designer. There is a consensus between artists that each professional has his/her own style or signature, making some of the designers identifiable based on their designs even without their explicit identification. On the other hand, there might be alternative good designs for a specific purpose, and choosing one from several, ties with the personal preferences of the user. Hence, providing alternative designs and allowing a user to choose one design based on his/her personal preferences is an added value to the function of automatic design systems. Accordingly, R-ADoMC implements the idea of design personalization to support the user. As the user works more with R-ADoMC and rates the generated designs, the rating data is accumulated for future designs.

There are three different approaches for recommending an item in current recommendation systems, content-based, collaborative filtering, and a combination of both these known as hybrid [5]. At this stage, our system does not consider any collaborative filtering because its personalization procedure is single-user based rather than multiple-user based. As Figure 9 illustrates, the system suggests the personalized design as an extra design, labeled as "your style." To anticipate this personalized design from the previous ratings of the user, we define the prediction of the ratings of the generated designs as a linear regression problem. To solve this problem, we use the LASSO algorithm [40] with L_1 regularization.

EXPERIMENTAL RESULTS

Figure 10 illustrates several ordered results. Generally speaking, the results generated by ADoMC are acceptable to our professional designers. However, a set of psychophysical experiments to evaluate the results by users is part of our future work. The system is implemented in Matlab and takes a few minutes to present the results (for a photo album of about 100 images), on a 64-bit PC machine with a 2-core 3GHz Intel processor and 4GB of RAM.

DISCUSSION

R-ADoMC is a recommendation system for the automatic design of magazine covers, and the purpose of this system is to aid the non-designer designer in creating aesthetically compelling designs. After a user uploads his/her photos, the system first suggests a number of semantic features, e.g., "elegant," "dynamic and active," or "sporty," to describe the color mood for the purpose of his/her design. Based on these high level features and a number of low level features, such as the complexity of a photo's visual balance, our system then selects the most suitable photos from the user's album for his/her design. Following this, R-ADoMC generates several alternative designs that can be rated by the user. Consequently, the system generates future designs grounded in the user's style, thus personalizing the designs based on his/her preferences.

The feedback that we have received from professional designers suggests that our automatic designs are aligned with their intuition. However, there is a need to devise a solid framework to evaluate R-ADoMC's generated results. This problem is highly correlated with aesthetics measurements. Quantifying aesthetics is still a challenge in computer science and engineering. In our case, while seeking a good solution by discussing this problem with our partners in the School of Visual and Performing Arts at Purdue University, we found that there might be several alternative good designs. So, we might be able to restrict the problem to what is a bad design. That inspired us to follow the principles of design. We believe that our work, among other previous work, emphasizes the need of devising and designing a set of measures and user experiments to evaluate aesthetics of the visual design. It is also worthwhile to mention that one dimension of aesthetics is beauty, which might be perceived through personal interest and experience, as suggested by Frohlich in "Beauty as a Design Prize" [12] and also by Barthes [7]. This viewpoint supports the notion of personalized design, or "Your Style," which, as suggested in this paper, may leverage the transcendental experience of beauty. Moreover, as Frohlich suggests, the perception of beauty can be stimulated by the inclusion of a more subjective experience in design. This is another support for the idea of recommendation for automatic design, as it considers the user's preferences. In fact, in interaction design, engaging the non-designer designer in the process of a design's creation by having a personal experience can arouse the experience of beauty, and hence, aesthetics.

Figure 10: Generated designs by R-ADoMC. The results are ranked from the first to third choice of design, from the left column to the right. First row shows a “Pretty”, “Romantic”, and “Elegant” color mood. Second row shows a “Classic”, “Natural” and “Cool-Casual” color mood. Third row shows a “Dynamic”, and “Modern” color mood. Photos courtesy of Andrew Hancock (a, e, g, h), Sean Molin (c, d, f, i), and Martin O’Connell (b).

Although our framework provides personalized designs, we endeavor to develop a framework which generates designs that are effective in both the function and form of aesthetics. Keeping this in mind, there are a number of limitations in R-ADoMC that must be addressed. One limitation is that we reduce the dimensionality of a design’s purpose to the color mood dimension, as well as visual complexity of the cover image. Although these two dimensions are important and influence the aesthetics of a design heavily, there exist other dimensions such as the objects in the cover image. This correlates with the context evaluations of the photos, and so these contextual factors need to be further investigated. Another limitation includes the hypothetical case that a user has an album of similar photos, e.g., all the photos are classified as modern in his/her album. While our system would provide several designs, we still require another feature or set of features to identify the ranking of these designs based on what the user needs. An additional limitation is that we do not consider specific typefaces for our typography, and this problem ties with the class of magazine, which contributes to defining a magazine’s style. We aim to address design based on the class of magazines within our future work.

Our current system, R-ADoMC, is a software framework meant to emulate the process that a professional designer attends to when creating a design. In fact, one of the key components of this framework is developing an interactive process between the software and the user to understand what kind of design the user needs or wants. As also indicated by Swearingen et al. [39], understanding the user's needs is important in designing the interactions of recommendation systems. On the other hand, designing interactions for recommendation systems can also be expanded to contribute to the idea of creativity support tools. Creativity support tools facilitate users to "explore, discover, imagine, innovate, compose, and collaborate" [35]. However, as indicated by Shneiderman [36], creative work often begins by viewing previous projects and similar samples. Since R-ADoMC recommends alternative designs to the user based on his/her preferences, it can be an underlying framework for a creativity support system in visual design. If the user is unaware of key concepts in design or principles of design, it is an added value to recommend these semantic descriptors that make sense to him/her and help to describe a design. It is, however, more ambitious to escalate the creativity of our non-designer user in the design of visual media. This desire requires a series of effective interactions between the user and the system to include the user in the creative process of his/her design. Hence, we endeavor to evolve R-ADoMC's framework into a creativity support tool for the process of visual design and concept design for media.

ACKNOWLEDGEMENT

We gratefully thank David Sigman, Head of The Patti and Rusty Rueff School of Visual and Performing Arts at Purdue University, Hector Sanchez, Design Director of Indianapolis Monthly Magazine, Ryan Kough Gibboney, Art Director of Purdue Alumnus Magazine, and Petronio A. Bendito, Assistant Professor of Visual Communication Design, The Patti and Rusty Rueff School of Visual and Performing Arts at Purdue University, for their input on our automatic designs. We also gratefully thank Elana Cutter, from the Department of English at Purdue University, for her editorial reviews and creative words, which we used in the automatic design samples. This work is supported by HP Labs, Palo Alto.

REFERENCES

1. Adobe Kuler. `http://kuler.adobe.com/`.
2. amanaimages EVE. `http://amanaimages.com/eve/`.
3. COLOURlovers. `http://www.colourlovers.com/`.
4. HP MagCloud. `http://www.magcloud.com/`.
5. Adomavicius, G., and Tuzhilin, A. Toward the next generation of recommender systems: A survey of the state-of-the-art and possible extensions. *Knowledge and Data Engineering, IEEE Transactions on 17*, 6 (2005), 734–749.
6. Allebach, J., Segovia, M., Atkins, C., O'Brien-Strain, E., Damera-Venkata, N., Bhatti, N., Liu, J., and Lin, Q. An investigation of document aesthetics for web-to-print repurposing of small-medium business marketing collateral. In *Society of Photo-Optical Instrumentation Engineers (SPIE) Conference Series*, vol. 7540 (2010), 13.
7. Barthes, R. *Camera lucida: Reflections on photography*. Hill and Wang, 1982.
8. Birkhoff, G. D. *Aesthetics Measure*. Harvard University Press, 1933.
9. Cohen-Or, D., Sorkine, O., Gal, R., Leyvand, T., and Xu, Y. Color harmonization. In *ACM Transactions on Graphics (TOG)*, vol. 25, ACM (2006), 624–630.
10. Datta, R., Joshi, D., Li, J., and Wang, J. Studying aesthetics in photographic images using a computational approach. *Computer Vision–ECCV 2006* (2006), 288–301.
11. Foges, C. *Magazine Design*. RotoVision Press, Switzerland, 1999.
12. Frohlich, D. Beauty as a design prize. *Human–Computer Interaction 19*, 4 (2004), 359–366.
13. Geigel, J., and Loui, A. Automatic page layout using genetic algorithms for electronic albuming. In *Photonics West 2001-Electronic Imaging*, International Society for Optics and Photonics (2000), 79–90.
14. Greig, D., Hunter, A., and Slatter, D. Layout hierarchies for interactive design reuse. In *Society of Photo-Optical Instrumentation Engineers (SPIE) Conference Series*, vol. 8302 (2012), 12.
15. Harel, J., Koch, C., and Perona, P. Graph-based visual saliency. In *Advances in Neural Information Processing Systems 19*, MIT Press (2007), 545–552.
16. Herring, S., Chang, C., Krantzler, J., and Bailey, B. Getting inspired!: understanding how and why examples are used in creative design practice. In *Proceedings of the 27th International Conference on Human factors in Computing Systems*, ACM (2009), 87–96.
17. Hunter, A., Slatter, D., and Greig, D. Web-based magazine design for self publishers. In *IS&T/SPIE Electronic Imaging*, International Society for Optics and Photonics (2011), 787902–787902–6.
18. Hurst, N., Li, W., and Marriott, K. Review of automatic document formatting. In *Proceedings of the 9th ACM Symposium on Document Engineering (DocEng'09)* (2009), 99–108.
19. Itten, J. *The Art of Color*. Wiley, 1974.
20. Jahanian, A. Automatic magazine cover design. Master's thesis, Purdue University, 2011.
21. Jahanian, A., Liu, J., Tretter, D., Lin, Q., Damera-Venkata, N., O'Brien-Strain, E., Lee, S., Fan, J., and Allebach, J. Automatic design of magazine covers. In *IS&T/SPIE Electronic Imaging*, International Society for Optics and Photonics (2012), 83020N–83020N–8.

22. Joshi, D., Datta, R., Fedorovskaya, E., Luong, Q., Wang, J., Li, J., and Luo, J. Aesthetics and emotions in images. *Signal Processing Magazine, IEEE 28*, 5 (2011), 94–115.

23. Knuth, D., and Plass, M. Breaking paragraphs into lines. *Software: Practice and Experience 11*, 11 (1981), 1119–1184.

24. Kobayashi, S. The aim and method of the color image scale. *Color Research & Application 6*, 2 (1981), 93–107.

25. Kuhna, M., Kivelä, I.-M., and Oittinen, P. Semi-automated magazine layout using content-based image features. In *Proceedings of the 20th ACM international conference on Multimedia*, MM '12, ACM (2012), 379–388.

26. Lavie, T., and Tractinsky, N. Assessing dimensions of perceived visual aesthetics of web sites. *International Journal of Human-Computer Studies 60*, 3 (2004), 269–298.

27. Lin, X. Intelligent content fitting for digital publishing. In *Electronic Imaging 2006*, International Society for Optics and Photonics (2006), 60760J–60760J.

28. Lok, S., and Feiner, S. A survey of automated layout techniques for information presentations. In *Proceedings of Smart Graphics*, vol. 2001 (2001), 61–68.

29. Lok, S., Feiner, S., and Ngai, G. Evaluation of visual balance for automated layout. In *Proceedings of the 9th International Conference on Intelligent User Interfaces*, ACM (2004), 101–108.

30. Ngo, D., Samsudin, A., and Abdullah, R. Aesthetic measures for assessing graphic screens. *Journal of Information Science and Engineering 16*, 1 (2000), 97–116.

31. O'Donovan, P., Agarwala, A., and Hertzmann, A. Color compatibility from large datasets. *ACM Transactions on Graphics (TOG) 30*, 4 (2011), 63.

32. S., K. *Color Image Scale*. Kodansha Intern, 1991.

33. Samara, T. *Making and breaking the grid: a graphic design layout workshop*. Rockport Publishers, 2005.

34. Samara, T. *Typography workbook: A real-world guide to using type in graphic design*. Rockport Publishers, 2006.

35. Shneiderman, B. *Leonardo's laptop: human needs and the new computing technologies*. MIT Press, 2003.

36. Shneiderman, B. Creativity support tools: A grand challenge for hci researchers. *Engineering the User Interface* (2009), 1–9.

37. Solli, M., and Lenz, R. Color semantics for image indexing. In *CGIV 2010: 5th European Conference on Colour in Graphics, Imaging, and Vision*, IS&T (2010), 353–358.

38. Sparling, E., and Sen, S. Rating: how difficult is it? In *Proceedings of the Fifth ACM Conference on Recommender Systems*, ACM (2011), 149–156.

39. Swearingen, K., and Sinha, R. Interaction design for recommender systems. In *Designing Interactive Systems*, vol. 6, ACM Press (2002), 312–334.

40. Tibshirani, R. Regression shrinkage and selection via the lasso. *Journal of the Royal Statistical Society. Series B (Methodological)* (1996), 267–288.

41. Tokumaru, M., Muranaka, N., and Imanishi, S. Color design support system considering color harmony. In *Fuzzy Systems, 2002. FUZZ-IEEE'02. Proceedings of the 2002 IEEE International Conference on*, vol. 1, IEEE (2002), 378–383.

42. Zhang, X., Gao, Y., Atkins, C. B., Cheatle, P., Xiao, J., Chao, H., Wu, P., Tretter, D., Slatter, D., Carter, A., Penny, R., and Willis, C. Autophotobook: using technology to streamline photobook creation. In *Proceedings of the SPIE*, vol. 7540 of *Society of Photo-Optical Instrumentation Engineers (SPIE) Conference Series* (2010), 75400L–75400L–15.