eMMaC: Knowledge-Based Color Critiquing Support for Novice Multimedia Authors

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ABSTRACT

Research in multimedia authoring has mainly focused on increasing features available to the title designer. While not arguing against rich functionality, we claim that simply adding more features to an already complex multimedia authoring system does not solve fundamental problems inherent in multimedia authoring tasks. Casual authors need knowledge-based support to harness the power of high-functionality authoring tools and produce *good* titles, ones which communicate the contents effectively and efficiently. This paper addresses the problem of color and image choice in static multimedia products. Cognitive research on color suggests a domain model which serves as basis for computer-based critiquing of color combinations and balance. This paper focuses on a knowledge-based mechanism, eMMaC, which critiques the use of color in a title under construction, describes the theory underlying the critique, suggests appropriate color usage, and helps users benefit from belonging to a community of users.

KEYWORDS

human factors, knowledge-based authoring environments, critiquing, color usage, usability, user interfaces

INTRODUCTION

The implicit assumption behind most multimedia authoring tools is that users have a clear goal in mind and only need more powerful mechanisms to achieve it. This viewpoint underestimates the domain knowledge required to produce good titles [3]. There are essential facets of multimedia authoring which technology will not solve. An excellent title is the result of knowledge, expertise, and skill, but not necessarily powerful tools. In the domain of user-interface design, for instance, though sophisticated user interface construction kits decreased the overall effort required for creating an interface, they did not automatically lead to the production of more useful interfaces, the design of which requires knowledge of user interface design as well as the application domain. In the same way, creating multimedia titles requires multimedia expertise in addition to knowledge about the content domain.

This paper argues that as multimedia authoring tools become more wide-spread and accessible, the lack of domain expertise, rather than the lack of sophisticated tools, will hamper the ability of novice authors to design titles. Multimedia novices, who are not interested in becoming professional graphic artists, but want to use multimedia as an enabling technology, need support to produce *good* products. Well-designed multimedia titles convey information content effectively and efficiently.

Multimedia technology enhances the ability to represent and communicate information in many domains. For instance, software engineers use animation for requirements analysis, hypermedia for on-line manuals, and movies for bug-reports. Just as laser printers led at first to a proliferation of "fontitis" (the maximum number of fonts on a single page) resulting in illegible documents, so will multimedia authoring tools lead to the chaotic use of color, sound, image, and video. Multimedia has the feature that it is easy to overspecify a point. For example, what used to be illustrated by a simple sketch can now be illustrated with a high-resolution photograph. The problem is that photographs differ from sketches in that they contain additional information that may not be relevant to the point [15]. Though they add visual appeal, they also add irrelevant information, such as weather or subjects. This can distract or even mislead readers.

This paper focuses on a knowledge-based mechanism which critiques the use of color in a title under construction, describes the theory underlying the critique, suggests appropriate color usage, and helps users benefit from belonging to a community of users. Color usage is an important aspect of multimedia titles. What are the most salient features of color that expert multimedia designers know and novices do not? Though hard rules do not abound, studies in visual communication design suggest theories and guidelines about human color perception, cultural associations of color, and appropriate color combinations [1, 26, 30, 16, 10, 29, 22, 31], which novice multimedia designers ignore at the expense of the reader. Our research attempts to bring this knowledge to bear during the design of a multimedia product. Our research question in this paper is, "*How can we provide novice multimedia authors with knowledge about good color usage?*"

In this paper, we first present cognitive issues in multimedia authoring for novices. Then we briefly describe our knowledge-based design environment approach as a framework, and present its computational critiquing mechanism. Though the eMMaC (Color Critics in Environment for Multimedia Authoring) component is designed as part of the whole design environment (eMMa) [19], eMMaC can be used as a stand-alone tool in the current implementation. We illustrate strengths and weaknesses of this approach via a detailed scenario and then conclude with future work.

KNOWLEDGE-BASED SUPPORT FOR MULTIMEDIA AUTHORING

Cognitive Issues in Multimedia Authoring

The single most important barrier novice multimedia authors face in creating good titles is not a technological problem, but the problem of expertise or knowledge about multimedia design.

A survey of commercially available multimedia authoring tools shown in Table 1 illustrates the common (and misguided) assumption that more functionality leads to a better product. From release to release, these products appear to have been "improved" with an overwhelming number of highly domain-specific commands, such as "gaussian blur" and "KPT sharpen intensity." Novice authors have to learn not only how to use the command, but also when it is appropriate, and what side effects result from its use. Research in multimedia authoring has been investigating representations which simplify the manipulation of information intertwined with the time dimension, for example, programming-like languages [12] and direct-manipulation style graphical interfaces [11]. Such computational support is only useful for expert users who already know what they want to achieve and how to achieve it. This population is shrinking rapidly in relation to experts in other domains who are beginning to want to take advantage of multimedia.

In multimedia authoring, goals vary from functional requirements (e.g., "an instruction manual for a product used mostly by elderly people" or "a conference schedule") to abstract concepts (e.g. "warm titles" or "relaxed atmosphere") to specific constraints (e.g., to use a corporate color "blue"). Authors need to map these intentions to detailed design decisions of authoring titles, such as color usage, sound and image associations, whether to use human or computer-generated voice, etc.

The mapping process requires knowledge both in the domain of each media, and in the domain of "multiple-media" representations. For example, in choosing color, there is knowledge such as "red and orange provide a warm atmosphere" [26] or "avoid red and green in the periphery of large-scale displays" [16]. In combining multiple media, knowledge such as "active processing of two concurrent sources of speech output is highly stressful" or "users can attend to more than one modality if they share common topics" [3].

Novice multimedia authors do not have well-formed goals and plans. They suffer from a lack of knowledge of the interdependencies between understanding problems and identifying existing tools to solve these problems. Unfamiliarity with this mapping leads authors to concentrate too quickly on implementation issues, and they often overlook alternative solutions.

When confronted with a highly complex system, there are several hurdles novice users face [6, 7]. First, users do not know about the existence of information. The system contains much more than the user even knows exists. Second, users do not know how to access information. Multimedia systems are getting to the point of complexity where knowing something exists is not enough to be able to find it. Third, users do not know when to use information. So little of the functionality of a complex system comes with examples of when it is appropriate to use a certain function.

Multimedia authoring is a design task. Design tasks, such as architectural design, mechanical engineering design, software design, writing, or music composition, require human creativity and judgment. Design tasks are *ill-defined* [28] or *wicked* [24] because the processes of identifying design intentions (problem specification) and constructing a concrete design representation (solution construction) are intertwined. Our approach to support multimedia authoring as design task focuses on augmenting human design activities with *domain-oriented, knowledge-based design environments* [9].

Design environments are computer systems that contain design tools and information repositories that designers use for understanding, reflecting on, and creating their designs. The environments support designers in coevolving problem-understanding and solution-building by monitoring designers' activities and delivering design knowledge relevant to the task at hand. The critiquing component described below is one of these kinds of knowledge delivery mechanisms.

Table 1: Functional Complexity of Commercially Available Multimedia Authoring Tools

(Note that there are additional 25 - 30 commands associated with the "File" and "Edit" menus.)

Application Name	**Size**	**Number of commands in the first level Menus (at the start-up state)**	**Manual Size •pages •on-line**
MACRO MEDIA DIRECTOR	3M	14 (Display) + 14 (Cast) + 17 (Score) + 17 (Format) + 504 commands in LINGO language	1668 pages 418M
MACRO MEDIA SoundEdit16	1M	7 (View) + 13 (Sound) + 21 (Effect) + 2 (Window)	258 pages 26K
Adobe Premier 4.0 (for Macintosh)	8.8M (incl. 3.5M plug-in)	11 (Project) + 7 (Create) + 16 (Clip) + 10 (Window) + 180 Plugin Modules	351 pages 14.9M
Adobe Photoshop 3.0J (for Macintosh)	12.6M (incl. 2.7M plug-in)	11 (Mode) + 32 (Image) + 47 (Filter) + 13 (Selection) + 6 (Window) + 100 Plugin Modules	832 pages 8.4M

eMMaC : A Color Critiquing Component of a Knowledge-Based Environment for Multimedia Authoring

eMMa (**e**nvironment for **m**ulti**m**edia **a**uthoring) is based on the multifaceted architecture for domain-oriented knowledge-based design environments [9] and was created in a project "*Supporting Creativity in Representing Information*" funded by Information technology Promotion Agency, MITI, Japan. The overall architecture of eMMa is described in [19]. This paper focuses on the critiquing component, eMMaC, which has been prototyped to investigate knowledge about color usage.

Critiquing is a dialog in which the interjection of a reasoned opinion about a product or action triggers further reflection on or changes to the artifact being designed. Computer-based critics are made up of rules or procedures for evaluating different aspects of a product [8, 27].

Previous experience with computational critiquing systems [8, 21] demonstrated that critiquing systems support designers in: (1) refining both the specification and the solution, (2) learning new domain concepts, and (3) articulating previously tacit domain knowledge triggered by critiques [20]. We have applied a computational critiquing approach in supporting multimedia authors in the use of color. The goal of the color critiquing component eMMaC is to:

- help designers use color appropriately based on research in both human color perception and the history of color across cultural boundaries;
- leave designers room for creativity - the system does not force designers to follow critiques but augments their skill and ability; and
- help designers articulate and accumulate domain knowledge.

Figure 1 illustrates the architecture of eMMa, a component of which is a color-critiquing component, eMMaC. eMMaC uses a community knowledge-base, which contains knowledge (critiquing rules) about color perception and color theory. This knowledge is based on research in human visual perception and the history of color usage in different cultures. Thus, the type of knowledge varies from scientifically sound rules to notes about historical usage and rules of thumb.

eMMaC takes into account the author's goals specified in the specification component of eMMa (eMMa-SPEC). The specification is used to identify applicable critiquing rules from the knowledge-base and enable those rules [18]. eMMaC analyzes any bit map; a user selects an area on the screen and invokes eMMaC. eMMaC then analyzes the bit map image by applying the enabled critiquing rules, identifies rule violations, and displays critiquing messages. The displayed critiquing messages are linked to arguments stored in the community knowledge-base, which provides detailed discussion about the critiquing rule. The next section details this.

COLOR CRITIQUING IN EMMA

eMMaC is written in Visual Works® Smalltalk and runs on several platforms. While originally intended to be one of several knowledge-based components of eMMa, eMMaC has been redesigned so that it will work with any authoring tool. This makes it useful to multimedia novices regardless of the environment they are learning.

Much research has been done in the use of color, theories of color, and physiology of color. For example, the Munsell Color system uses hue, value and chroma to represent a color [26]. Hue is the name of the pure state of color or chromatic group, determined by its wavelength. The Munsell system has five principle and ten secondary hues. Value represents lightness or darkness of a hue, also called as brightness, luminosity, reflection, tint, or shade. The Munsell system has nine value levels,

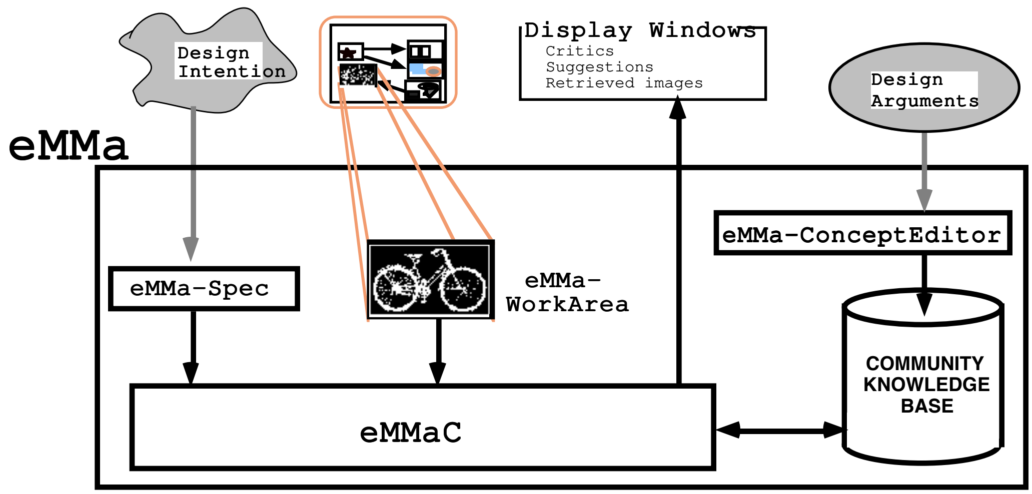

Figure 1: Critiquing Component in eMMa

The critiquing component (eMMaC) takes into account the designer's goals and intentions for the authoring task (eMMa-SPEC), identifies relevant critiquing rules from a community-knowledge-base, and analyzes a bitmap image given in the eMMa-Workarea. The other components are further described in [19].

ranging from pure black to pure white. Chroma is the strength of a hue at a certain value, also called purity, saturation, or intensity. To describe how eMMaC works, we present a scenario in three sessions. Each section begins with a description of a user interaction with the system, then describes the problem of interest, and any relevant system mechanisms. The scenario is about a multimedia title author Joy, who wants to produce a title to describe how to maintain a bicycle.

Color balance and associations

Scenario-1

Joy creates an image of a bike with PhotoShop, colors the bike yellow and the background purple. Joy selects this area on the monitor and asks for a critique. eMMaC displays the critiquing window, which states "the balance of purple and yellow is not appropriate," and shows her a copy of the image, with a much lighter yellow instead. Also, the system shows a list of associations of the color purple (see Figure 2). Note that the preference ratings for purple are higher for adults than children.

Color Balance. eMMaC creates a histogram of colors and identifies the two most frequently used colors. In the above scenario, purple and yellow are identified as the two primary colors in the area of Joy's partially constructed title. The system computes the balance between the two colors using the Munsell color scheme algorithm [26]. The algorithm uses the inverted ratio based on the numbers to identify the balance; for example, Yellow is 96, Purple is 24, so the ratio of Yellow to Purple should be 24:96, or .25. The system computes the area used for Yellow and Purple, in this case, 26%:72% = .36. If the ideal ratio deviates from the actual ratio by more than 10%, the system suggest that the balance is inappropriate.

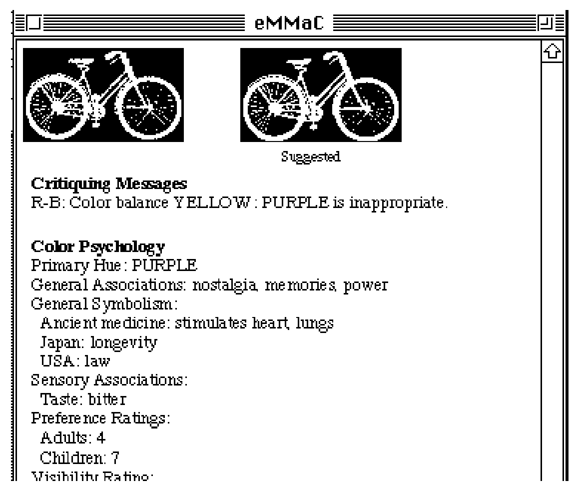

Figure 2: eMMaC

An Image of a yellow bike with a purple background is critiqued along with a list of associations for the color purple.

At the same time, the most frequently used color, in this case, purple, is assumed to be a theme color by the system, and the system adjusts the secondary color according to the area computed. For example, since the area is .36, the Yellow-Purple ratio should be .36. The number of Purple is 24, so the ideal yellow color is 24/.36 = 67. The system looks for candidates of yellows that have the number 67, and chooses the median, then changes the color to the computed color and presents it as a suggestion (i.e., lighter yellow, in the above scenario).

Color Association. eMMaC also provides cultural associations of colors in the form of a hypermedia argumentation-base. A basic set of concepts is in the system and more can be added by the user. They are also used in eMMaC-SPEC as described below.

eMMa-SPEC and Tuning Critiquing

Scenario-2

Joy looks at the critiquing messages and the modified image. Now she has learned some social associations of purple, and notices that adults like purple more than children. This reminds her that the title is in fact for children. She opens up eMMa-SPEC and specifies design goals by selecting "children" and "instruction" from the menu provided by the system, then adds "bicycle" as a new concept (see Figure 3). She also selects yellow as a theme color. She asks eMMaC to critique her partially constructed title again, and is informed that "Color balance yellow:purple is inappropriate" but this time, it adjusts the background purple color to a lighter purple. Another critiquing message says that yellow is not preferred by children.

eMMa-SPEC. eMMa-SPEC is a goal specification component, to fine tune the critiquing behavior (see [19] for detail). For example, in the first scenario, the system provided only generic level suggestions and guidelines for the use of color. Through studies of critiquing systems, we have learned that critiquing should take into account the user's goals [21].

eMMa-SPEC (Figure 3) offers three types of representations for specifying user's goals: a theme color, textual concepts, and freehand sketches. Users can select a color by either clicking on a color pixel anywhere on the display, selecting from a menu of color names, or using a color picker. Color names are based on [10], and users can define new names.

The user selects textual concepts from a pop-up menu or creates new ones. Predefined concepts include: color temperature (e.g., warm, cool), atmosphere (e.g., happy, sad, cheerful), types of titles (e.g., instruction, entertainment), target age (e.g., children, adults, elderly), and geographic and racial culture (e.g., Japan, Greece, USA). The concepts representing atmosphere are from [13], which maps emotional phrases to a warm-cold and light-dark two dimensional space, and from [26]. The specified concepts are used to identify relevant critiquing rules (see below).

Finally, eMMa-SPEC allows users to add freehand sketches to the goals. They may use this as a rough draft of an interface design, or representing the content of a title, for example, a mountain bike.

Tuning Critiquing: Specific Critics. Based on eMMa-SPEC, eMMaC identifies: theme color, concepts represented in eMMa-SPEC, but the current implementation does not yet take into account the freehand sketches.

eMMaC will not change the theme color when balancing colors even if it is not the dominant color. The default theme color is the dominant color; for example, purple in the above scenario. Since Joy explicitly specified yellow as theme color, the system did not change yellow, but adjusted purple to get the appropriate balance. If the specified theme color is neither the first nor second most frequent color then the system calculates the balance between the specified theme color and the dominant color. Some images have a background color which is supposed to be transparent, for example GIF images which use the background of the window in which they are displayed as their own background. To accommodate this, eMMaC allows the user to specify a list of colors to ignore so that they do not affect any calculations.

Critiquing rules represent interdependencies between concepts and colors [19]. Concepts and colors are linked with a positive or negative link. For example, the concept "warm" is linked positively to "orange," "red" and other "reddish" colors that reside in the spectrum of warm colors defined in most color literature. The concept "children" is negatively linked to yellow, and the link is associated with an argument, "in many cultures, yellow is not favored by children." eMMaC identifies such interdependencies that are related to concepts in eMMa-SPEC and checks the existence of specific colors associated with negative links. For detailed mechanisms, see [19].

Color Palettes and Image Retrieval

Scenario-3

Having seen the critiquing message "*Theme color has low Preference rating for Children*," Joy does not accept the critique, because yellow is the color of the children's bike club. So she makes an annotation in the argumentation base saying that "Though intended for children, yellow is used because it is the team color." She adds a new concept "Organization Color" and specifies that yellow is the organization's color. Joy wants to find color combinations with the theme color she has specified (i.e., yellow) and asks for "Suggested Color Combinations." eMMaC presents sets of color palettes. Joy also asks for "Suggested Images," then eMMaC presents her with several images which have yellow as a dominant color (see Figure 4).

Suggested Color Palettes. Based on the theme color (or the dominant color as default), eMMaC presents appropriate combinations of colors to suggests as color palettes. The combinations are similar to the Munsell Color System 3-D space combinations [26].

Image Retrieval eMMa's community knowledge-base offers a library of 1,000 public domain images, including photographs, graphics, and icons. The system allows users to retrieve images based on the use of color,

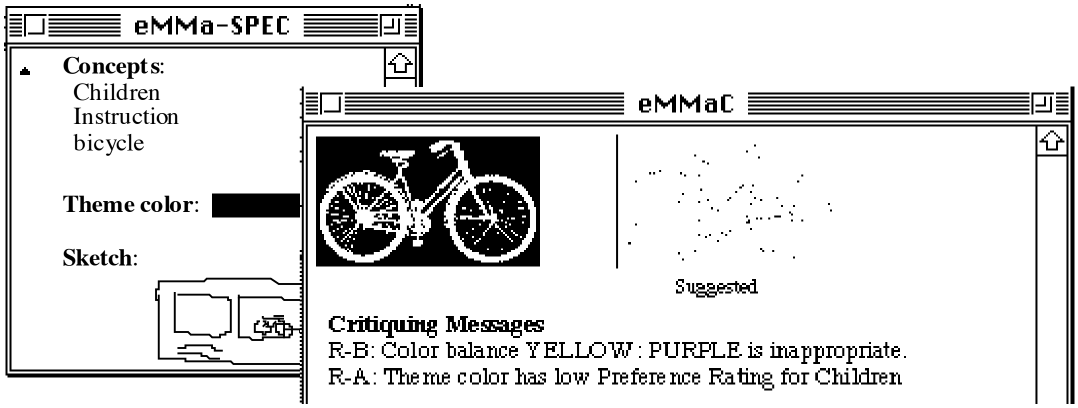

Figure 3: eMMa-SPEC

Children and Instruction are concepts chosen from the menu. The user typed "bicycle."

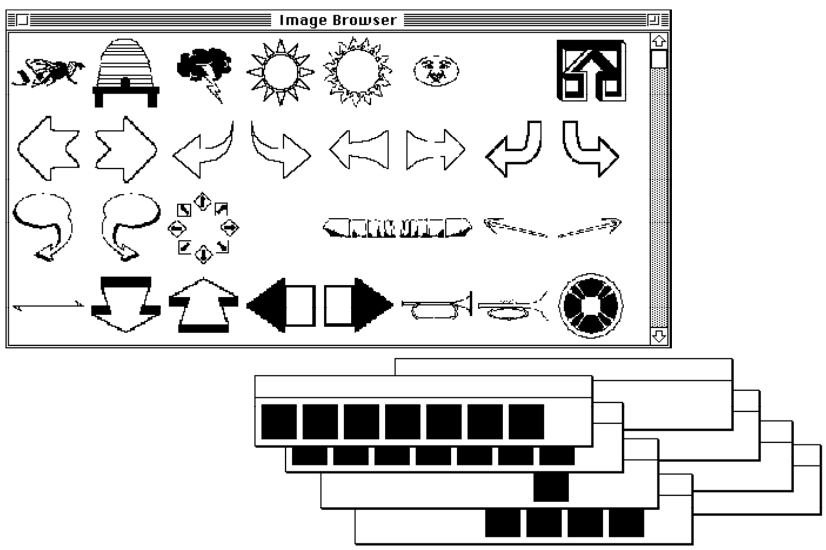

Figure 4: Color Palettes and Retrieved Images

the center of gravity, and brightness [2]. Each image of the library is associated with color histograms and in this scenario is used to retrieve images that have yellow as the dominant color.

Summary of eMMaC

In summary, eMMaC provides the following services:

1. *Color combinations*. when a user selects a theme color, the system provides the user with several color combinations based on various movements through the color-space.

2. *Color balance*. The system identifies inappropriate balance between two colors; e.g. a theme and secondary color, or the two most frequently used colors. It illustrates the critique by copying the user's image and adjusting the balance.

3. *Color association*. The system presents associations of the theme color and identifies inappropriate use of colors in terms of abstract concepts specified in eMMa-SPEC. For example, the concept of warm colors (red, orange, etc.). The system checks for the absence of positively linked colors from the specified concepts in eMMa-SPEC, or the existence of negatively linked colors from the specified concepts in eMMa-SPEC (see Section 3.2). The descriptions of associations are provided in the argumentation-base, which is implemented as a

hypermedia system. The system allows users to annotate an argument by adding a node to the hypermedia system.

DISCUSSION

The mechanisms presented in this paper are based on theories of design and assessment of previous efforts in knowledge-based support for design tasks [9, 20]. The two most important multimedia authoring challenges are: what design decisions to make so that the product results in an effective and efficient title, and how to implement the design decisions. We have argued that existing multimedia authoring tools assist users only in the latter. We are building a system that complements existing tools by assisting users with the first challenge. eMMaC augments authors without depriving them of the impressive functionality provided by existing tools.

In this section, we evaluate our approach in supporting multimedia authoring, describe how to support the evolution of the knowledge-base, and discuss future directions.

Applying the Critiquing Approach to Multimedia Authoring

Rather than building expert systems [4] that automatically produce a "good" multimedia title, we have taken the critiquing approach that supports and augments people in authoring titles. Relative to most critiquing systems that evaluate a solution in terms of generic domain knowledge [27], our critiquing system is unique in that:

- it provides a specification component to describe the user's design goal, which enables the system to critique a partial solution in terms of the specified design goals. This allows users to refine not only the partial solution but also the partially stated design goal;
- it relates domain specific argumentation to the current task. Users may annotate and argue with the critiques if necessary. The modifications and additions will serve to improve the community knowledge-base; and
- it deals with non symbolic representations by using a scheme to map a color to symbolic representations [10].

eMMaC addresses several fundamental barriers to complex system use as follows.

Users do not know about the existence of information. eMMaC contains knowledge specific to the domain of color theory. It informs the user of knowledge related to color selection. The user need not ask specifically about color balance, for example, because eMMaC knows when it is appropriate.

Users do not know how to access information. A brief perusal of the documentation for any of the high functionality authoring systems should convince the reader that knowing that certain information exists in the system is still not enough to be able to find it. eMMaC was intended to operate in an environment where it had access to the underlying representations and could thus address this point, but the first prototype has instead been implemented in a platform independent way. We are continuing to study this issue.

Users do not know when to use information. Critiquing is particularly suited to address this problem, because at its best, a critique brings the most relevant information to bear on any specific task.

Knowledge-base Evolution

Domain knowledge for multimedia authoring is immature, requiring continuous growth and refinement. One cannot develop a complete knowledge-base for supporting multimedia authoring, because tacit design knowledge exists in any design domain [23]. Since it is impossible to completely codify design knowledge but only the parts that have been articulated, computer systems can have only limited design knowledge in their knowledge bases.

eMMa starts with a small, incomplete knowledge-base as a seed. Then eMMa's critiquing mechanism supports the cycle of *knowledge delivery* and *knowledge elicitation from users*, which contributes to the gradual evolution of the knowledge-base [20]. Our previous user studies with knowledge-based critiquing systems in other domains [17, 20] demonstrated that the system's critiques (1) invoked designers' reflective thinking, (2) made designers aware of tacit design knowledge, and (3) caused designers to disagree with the system and provide new domain knowledge. That is, the system encouraged designers to articulate critiques to the current situation as knowledge elicitation. The elicited and stored knowledge was taken into account by the system to change the subsequent behavior of the system. Technical details for these mechanisms are provided in [17] and [19].

Although the current system provides a single community knowledge-base, we foresee that as the domain matures, domain-specific multimedia authoring knowledge will emerge. Also, as discussed below, as multimedia representations depend on cultural background, it is important to partition a knowledge-base according to the specific types of design goals [21]. A knowledge-base can be partitioned according to a perspective for an authoring task, and authors can specify which perspective to use through eMMa-SPEC. Issues such as how to maintain consistency and eliminate contradiction, and how to support the growth and reorganization of the knowledge-base need to be considered.

Future Work

Application to Other Media

This paper presented a knowledge-based support mechanism in the domain of color. We are extending our framework to the domains of sound, image, and the integration of multiple media.

In the domain of sound, there has been research in computer-generated music and emotional associations

[13]. We have also conducted our own experiments asking subjects to associate images to music. Although the analysis is still in progress, there are already interesting findings such as: 1) it seems easier to associate music with a photograph than to an icon, and 2) music associations are highly dependent on culture.

Lohse et al. [15] discuss classification of images. They and other researchers have identified several rules that appear to novices to be quite counter intuitive, such as "photo-realistic images convey less information than other types of images," "using less complex, more schematic icons enhances identification and memorability, because irrelevant elaborate details about pictures are not easily discriminated from simpler versions of the target pictures without the elaborate details." The system can use techniques to automatically process images (such as discussed in [5]) for more content-oriented critiquing.

Although domain knowledge has been constructed in each sub domain of multimedia, such as sound, color, images and videos, we do have not yet have a good understanding of integral usage of multimedia, which integrates a variety of media with the time dimension. Although Bearne et.al. [3] suggest formalizing usability guidelines for multimedia titles, we have taken a human-computer cooperative problem solving approach in which rules and guidelines are *soft* - they are subjective and arguable by people. To effectively serve this purpose, the community knowledge-base must be modified over time.

Representation of design intent

Currently, the specification component (eMMa-Spec allows users to post concepts, draw sketches, and select a theme color as representations for design goals. Such explicit representation of design goals support users in two ways [17]. First, exposing implicit goals helps people to decrease the cognitive load of remembering and allows them to reflect on their problem statements. Second, such representations serve as shared understanding between the system and users and allows the system to critique "the right thing at the right time in the right way." More empirical research needs to be done to study what types of representations (symbolic and non symbolic) multimedia title authors have in mind as design goals. We will also investigate the possibility of using case-based reasoning [14] to use a multimedia title itself as a specification of design intention. The system could then help users identify and construct similar titles.

Culture

As multimedia uses human cognition and social background, we should not underestimate the effects of cultural differences. More attention should be paid in designing cross-cultural multimedia titles because concepts associated with non symbolic media largely differ across cultures [25, 18]. People in different cultures have different ways of organizing and performing tasks and use different representations based on different norms.

There are two major cross-cultural issues. First, we need more empirical studies to identify cultural factors, and employ studies from outside of computer science, such as ethnography. Second, we need to uncover implicit underlying design concepts of a title which might be culture-dependent.

Towards a Fullfledged Multimedia Authoring Environment

The current implementation can only deal with bitmap images. As a consequence, suggestions made by the system (such as adjusted colors) need to be mapped to the authoring tools by users. Ideally the system would have access to the underlying representation so that it could carry out some of the recommendations, rather than just making them on a copy of the image. We are looking at inter program communication standards such as DLL and AppleEvents.

CONCLUSIONS

The research contributions in this paper are twofold. First, it is an early attempt to apply a computational knowledge-based critiquing approach to a non symbolic domain, such as color. Numerous critiquing systems have been studied in a variety of domains, including kitchen design, user-interface design, local-area network design, and voice dialogue design. Over the course of this research, we have discovered that the challenge when building such systems is not simply to deliver information; the challenge was to deliver relevant information in a timely manner. In pursuit of this challenge, we have explored various mechanisms to increase the designer's control over the activities of the critiquing system. The same architecture and framework has shown to be suitable for non symbolic domains, such as color.

Second, it is a novel attempt to help novice multimedia authors produce "good" multimedia titles. Multimedia authoring is here viewed as an ill-defined design task, to which we have applied our knowledge-based design environment approach. eMMaC users are not only supported in producing multimedia titles but they also have the opportunity to learn about the underlying domains, in this example the domain of color. Newly identified domain knowledge is accumulated in the system to construct a community knowledge-base which grows with users over time.

ACKNOWLEDGMENTS

We thank Gerhard Fischer and the members of the Center for Lifelong Learning and Design (L3D) at the University of Colorado who contributed to the conceptual framework discussed in this paper. We would also like to thank Kaoru Hayashi at the SRA Boulder office for early discussions. This idea was originally explored by Mina C. Johnson as course work at the University of Colorado. This research was supported by Information Technology Promotion Agency, MITI, Japan.

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