RAG-Based Platform for the Semantic Translation and Intelligent Design of Traditional Chinese Colors

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Abstract. The traditional Chinese color system contains unique cultural concepts and philosophical expressions, and has important application value in contemporary design. However, its semantic ambiguity and insufficient retrieval efficiency limit its practical use. In order to cope with this challenge, this study proposes a semantic color conversion framework based on retrieval enhancement generation (RAG) algorithm. By constructing a five-dimensional data model suitable for multi-source unstructured data and combining it with RAG technology, an intelligent design platform based on WeChat applet is developed. With the help of high-dimensional semantic embedding and cosine similarity calculation, the system can accurately retrieve color entries related to cultural context, and realize the efficient transformation from natural language to traditional Chinese color scheme, thus providing an extensible solution for the transformation of traditional color semantics into practical design applications. The method proposed in this study also provides an extensible reference path for the construction of other cultural and knowledge-based information systems.

Keywords: traditional Chinese colors, Retrieval-Augmented Generation, intelligent design platform

1. Introduction

Since the cave murals thousands of years ago, the ancients have used color in practical applications [1]. The ancient civilization initially adopted the monochrome system, while the five-color system was invented during the reign of Emperor Shun [2]. The color used by Chinese people is not only related to physical attributes, but also carries cultural significance involving philosophical, historical, sociological and literary studies [3]. Color shows the way humans perceive the universe, and has made great contributions to different fields such as textiles and painting [4]. In the process of global cultural digitization, traditional colors face both challenges and benefits. The ability of digital technology to imitate and interpret cultural symbols is one of its major advantages [5]. However, the traditional color in Chinese culture is often poetic and ambiguous, which makes it difficult for designers to understand its origin and significance [6]. In addition, due to the lack of knowledge reserve and poor retrieval ability, it is difficult for designers to integrate it into modern

design. Although the development of artificial intelligence technologies such as large-scale language models and multimodal learning provides new possibilities for semantic analysis [7], the analysis results of general artificial intelligence models in some cultural regions may not be accurate enough.

To resolve the above problems, a Retrieval-Augmented Generation (RAG) model is proposed in this study. This model sorts and organizes various types of data associated with colors in a database and conducts a retrieval process during generation. Based on this model, an intelligent system for color recommendation in terms of traditional Chinese colors is designed. The system can automatically convert natural language information into specific color information and cultural meaning of colors.

2. Theoretical foundation

2.1. Cultural significance of traditional Chinese colors and their contemporary design applications

The traditional color system of China, popularly referred to as the "five color system," originates from the philosophy of ancient China and is based on five basic colors including blue, red, yellow, white, and black [8]. The traditional color system goes beyond being concerned about classification of colors in relation to appearance of different items and objects. Rather, it forms an integral part of Chinese culture, associated with the Five Elements (五行), Five Directions (五方), and Five Constant Virtues (五常) [9]. Consequently, colors are symbolic in the context of representation of various cultural values including social hierarchy, ethics, emotion, and spirituality [10].

With regards to today's world, due to the rising impact of globalization, there has been an increasing emphasis on cultural identity, hence the development of Neo-Chinese styles. The designers would like to use Chinese colors in modern times. However, the challenge involved in this case would be that of semantic translation. In modern days, colors have numeric codes while Chinese colors have names [11]. The implication of Chinese color can be derived from both nature and literature. As shown in Table 1, "Hai Tang Red" not only reflects its color itself, but also contains the image of spring flower scene. The problem is that this makes it difficult for designers to use these traditional colors because they cannot be converted into digital code.

Table 1. Traditional Chinese color names, sources, and meanings

Color Name	Color source	Color Meaning
Lu He	Tao The Ching	warm and soft
Hai Tang Red	Begonia flower color	bright
Qi Blue [12]	Er Ya	elegance and freshness
Tao Hua Lang [13]	Book of Songs	beautiful appearance
Tian Qing	Wu Za Zu	pure

2.2. Technical logic of the RAG algorithm

With the rapid development of artificial intelligence technology, the evolution of design paradigm has also emerged. In terms of design methodology, the external knowledge base and large language model based on RAG architecture can be used to complete part of the design efficiently [14]. As shown in Figure 1, there are mainly three major modules of RAG: indexing, retrieval, and generation. In the indexing phase, a knowledge base is built based on various sources of data. For

the retrieval process, information related to the query can be extracted with the help of embedding vectors. For the generation phase, the retrieved information along with the query is used to generate corresponding outputs [15]. By comparison with previous methods, RAG addresses the issue of knowledge hallucination in general models, ensuring the reliability of results. The retrieve-then-generate procedure helps achieve the proper incorporation of knowledge within specific domains, which makes it suitable for tasks involving cultural knowledge, such as the use of traditional Chinese color theories in contemporary design projects.

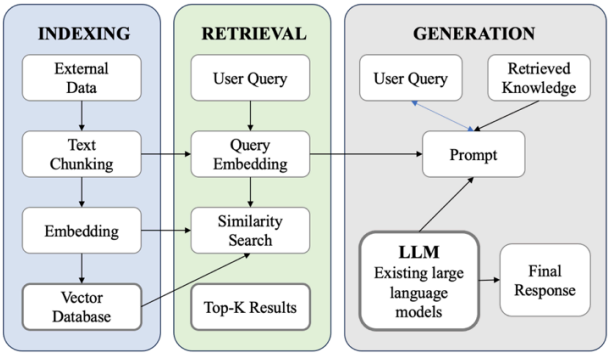


Figure 1. Architecture of the RAG framework

3. Construction and formatting of a traditional color knowledge base for RAG

3.1. Data source collection and preprocessing

This study selected The Colors of the Nation: An Illustrated Guide to Traditional Chinese Color Schemes as its primary data source [16]. The color information compiled in this book is based on research into representative classical texts such as The Book of Documents, The Book of Songs, and Tian Gong Kai Wu. The introduction of positive color, intermediate color and color matching scheme in the book can be more efficiently corresponding to a five-dimensional data model. As shown in Figure 2, this book adopts the traditional five-color model and combines the colors used in modern design. The colors are organized into seven main categories: red, yellow, green, blue, purple, brown and black and white. This approach not only respects the background of the times but can be associated with the modern design process.

Figure 2. Seven categories of traditional Chinese colors

3.2. Construction of the knowledge ontology

In order to be able to use the computational model to process the traditional Chinese color knowledge written in natural language, this study proposes a five-dimensional data structure model, including "Primary Color", "Color Value", "Color Description", "Related Colors" and "Color Schemes". JSON format is lightweight and has a hierarchical structure, which is convenient for program analysis. The format supports efficient vector processing and provides a clear interface for indexing and retrieval within the RAG framework. This study converts structured knowledge into a machine-readable data set expressed in JSON format. As shown in Figure 3, the model organizes each color in an interdependent manner in the above five dimensions. This structure can connect the cultural semantic information and visual features of color at the same time. The "Primary Color" dimension provides a standardized name definition for colors, while the "Color Value" dimension defines the values of colors in CMYK, RGB and HEX formats, which helps to apply color knowledge in practical design work. The dimension of "Color Description" expounds the cultural background and symbolic significance of different colors. On the other hand, the "Related Colors" dimension establishes a correlation network based on the similarity between colors, which makes it easier to find visually similar colors. The "Color Schemes" dimension contains a series of predefined color combinations that can be directly applied to design practice.

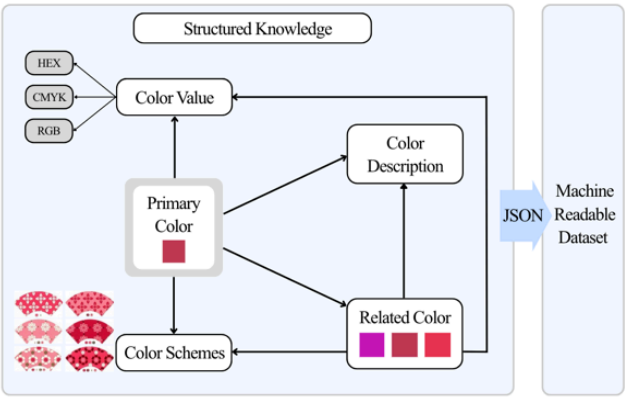


Figure 3. Five-dimensional data structure model for traditional Chinese color knowledge

4. Design and implementation of a RAG-based color semantic translation algorithm

The mapping between semantics and colors in the Chinese color scheme incorporates exact information based on ancient literature with the interpretation of images. Using solely the large language model may produce incorrect facts in some specialized cultures, but using only keyword matching is not enough to cover the variations of natural language statements. In order to overcome such constraints, the current paper uses the RAG approach. The method retrieves relevant information based on semantics from an organized knowledge source and uses this information when generating the outputs.

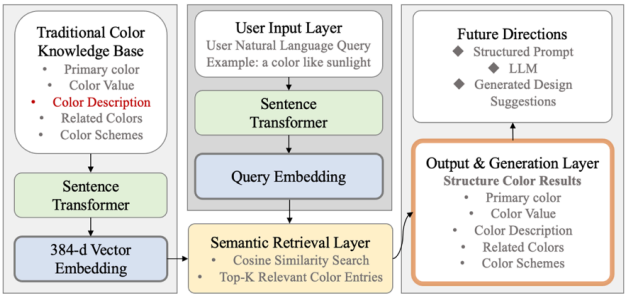


Figure 4. RAG-based semantic retrieval framework for traditional Chinese colors

As shown in Figure 4, the current research uses a Sentence Transformer model that supports multiple languages to map the color-related text information to a semantic space with high dimensions. Each entry regarding colors is encoded to become a normalized vector according to the information about the name of the color, its description, and other colors associated with it. In the retrieval stage, the content entered by the user is transformed into a vector through online processing. By comparing the vector with other vectors, the cosine similarity is used as the standard for similarity comparison. Finally, the top-K entries and their complete five-dimensional information can be retrieved. This strategy ensures that semantic matching can be performed within the framework of this study rather than exact matching, which means that the method can work effectively even in the face of abstract input such as abstracts, descriptions, or images provided by users.

5. System implementation and application validation

5.1. System overview

Based on algorithmic design, this study has developed the "Intelligent Recommendation Platform for Traditional Chinese Colors." As shown in Figure 5, the platform operates as a WeChat Mini Program and integrates a structured knowledge base with the RAG semantic retrieval algorithm. Through a user-friendly interface that includes modules such as search, navigation, color recommendations, and detailed information display, the platform has established a closed-loop application process that converts users' natural language inputs into intelligent color recommendations.

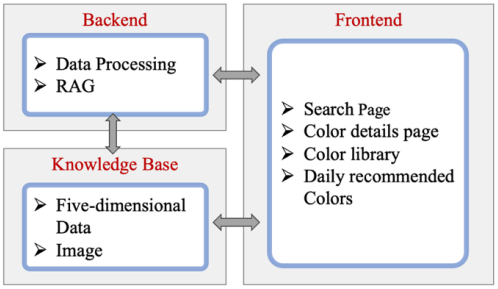
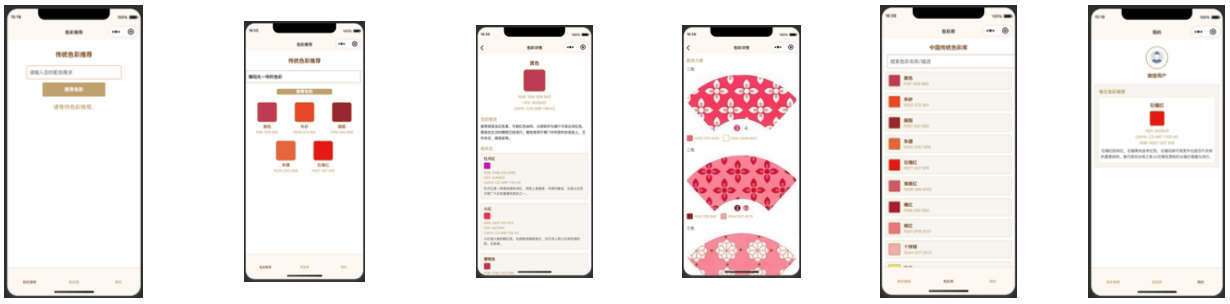


Figure 5. Chinese traditional colors WeChat Mini Program interface

5.2. System architecture and interaction design

The platform uses a standard three-tier structure. The backend is responsible for data processing and algorithm services; the knowledge base layer uses a five-dimensional model to store structured color data; the front end is implemented as a WeChat applet.



(a)Search (b) Top5 recommended colors (c) Color details page 1 (d) Color details page 2 (e) Color library (f) Personal Center

Figure 6. Chinese traditional colors WeChat Mini Program interface

As shown in Figure 6, the front end communicates with the back end by defining a clear JSON interface to handle user interaction and render the user interface. Figure 6(a) shows the situation where users enter natural language in the "Search" interface for queries. Figure 6(b) shows the return results of the system, presenting the five most relevant colors in the form of an interactive visual color card. As shown in Figures 6(c) and 6(d), each interactive color card is associated with a color detail page that includes a name, color value, description, related colors, and color scheme. Figure 6(e) shows the "Color library" module in the system, which supports both structured browsing and precise search. Figure 6(f) is a "Personal Center" module that manages user information and provides daily color recommendations. This feature helps to increase user participation and encourages users to continuously explore traditional Chinese color culture.

6. Summary and future work

The research proposes an innovative approach to the development of an intelligent design platform by combining traditional Chinese knowledge of color with the RAG framework. This is done by building a knowledge base and using semantic vector retrieval to bridge the gap between cultural semantics and computational representations. The methodology developed by this research provides an approach that can be scaled up to other forms of cultural and knowledge-based information systems, offering a potential route to the horizontal application of vertical artificial intelligence. Future research will be focused on enriching the knowledge base from a wider cultural context and improving the capabilities of the system by incorporating large language models and generative technologies to promote the sustainable development of cultural heritage in modern design.

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