ISSN (Online) 2394-2320

International Journal of Engineering Research in Computer Science and Engineering (IJERCSE)

Vol 12, Issue 03, March 2025

# Color Harmony Analysis and Outfit Recommendation

[1] M Adithya Vardhan, [2] Arjun Maddipatla, [3] MS.J.Sarojini Premalatha, M.E.,

[1] [2] [3] Department of Computer Science and Engineering, Sathyabama Institute of Science and Technology.
Corresponding Author Email: [1] adithya.m089@gmail.com, [2] harlequin.music777@gmail.com,
[3] sarojinipremalatha.j.cse@sathyabama.ac.in

***Abstract*— Color harmony is a critical aspect of fashion design and outfit coordination. This research presents a computational approach to analyzing color combinations in fashion datasets using HSL (Hue, Saturation, Lightness) color theory and web-based color naming tools. By converting hexadecimal color values to HSL format, identifying complementary and analogous colors, and generating recommendations based on item types and color harmony principles, this system provides a structured framework for automated outfit recommendations. Results demonstrate the efficacy of the approach, while also highlighting limitations in handling edge cases like neutral tones (black, white, gray).**

## I. INTRODUCTION

The integration of technology into the fashion industry has transformed how consumers interact with clothing, from online shopping to personalized outfit recommendations. In recent years, automated systems that analyze fashion data have become increasingly prevalent, offering solutions for mix-and-match recommendations based on design principles. Among these principles, color harmony stands out as a cornerstone in determining the visual appeal of outfits. This research delves into computational techniques to analyze and apply color harmony theories to generate cohesive outfit suggestions.

The foundation of color harmony lies in understanding the relationships between colors on a color wheel. Traditionally, designers relied on intuition and artistic knowledge to pair complementary, analogous, or contrasting colors. However, with advancements in computer science, these relationships can now be quantified and applied to datasets. By leveraging the HSL (Hue, Saturation, Lightness) color model, this research creates a structured approach to convert color values into actionable insights for outfit recommendations. The HSL model's intuitive nature and alignment with human perception make it a suitable choice for analyzing fashion datasets.

Fashion is not only about aesthetics but also about practicality and occasion-based choices. The context in which clothing is worn significantly impacts the choice of colors and combinations. For instance, formal attire often gravitates toward neutral or subdued tones, while casual and party wear may feature vibrant and experimental palettes. This study recognizes these contextual nuances and integrates them into the recommendation engine, ensuring that the suggestions are not only harmonious but also contextually appropriate.

Despite the potential of computational tools, challenges remain in automating fashion recommendations. Neutral tones such as black, white, and gray pose unique difficulties due to their universal compatibility and lack of distinct complementary hues. Additionally, the limitations of existing color naming databases can hinder accurate mapping of hex codes to human-readable names. This research addresses these issues by employing custom algorithms and refining the handling of edge cases, thereby providing a robust framework for automated outfit recommendations that align with contemporary fashion trends.

## II. LITERATURE REVIEW

### A. Color Harmony in Fashion Design Using HSL Model by Nguyen et al. (2019)

This paper explored the application of the HSL (Hue, Saturation, and Lightness) color model to analyze harmonious color schemes in fashion design. The authors demonstrated that HSL offers an intuitive framework for creating visually appealing combinations, particularly in automated systems. **Drawbacks**: The study did not address cultural influences on color preferences, limiting its generalizability across diverse audiences.

### B. Enhancing Outfit Recommendations with Complementary Color Theory by Smith and Taylor (2020)

This work applied complementary color theory to outfit recommendation systems, showing how contrasting hues can enhance aesthetic appeal. Their system aligned with user preferences and improved recommendation quality. **Drawbacks**: The model relied heavily on predefined rules, reducing adaptability to dynamic user inputs or new fashion trends.

### C. User-Centric Color Matching Using Deep Learning by Zhang et al. (2022)

This study integrated complementary color theory with neural networks to predict outfit combinations, achieving a 30% increase in user satisfaction. The model incorporated user feedback for adaptive recommendations. **Drawbacks**: The system struggled to handle subjective inputs effectively, and results were inconsistent under varying lighting

ISSN (Online) 2394-2320

International Journal of Engineering Research in Computer Science and Engineering (IJERCSE)

Vol 12, Issue 03, March 2025

conditions.

### D. Real-Time HSL Analysis for Outfit Adaptation by Kumar and Singh (2023)

This research focused on using real-time HSL analysis to recommend dynamic outfits based on environmental changes. Their system provided adaptive recommendations for color harmony in varying contexts. **Drawbacks**: The approach faced computational efficiency issues, particularly with processing large datasets in real-time.

### E. Towards Holistic Fashion Recommendations: Beyond Colors by Park et al. (2023)

The authors emphasized the need to integrate texture and pattern analysis with color harmony principles. They proposed an approach combining HSL metrics with advanced image recognition techniques. **Drawbacks**: Their model required extensive computational resources, making it less feasible for real-time applications.

### F. Cultural Perspectives in Color Harmony Analysis by Chen et al. (2021)

This study analyzed the influence of cultural and personal preferences on color harmony in fashion. It highlighted the variability in aesthetic perceptions across different demographics. **Drawbacks**: The research lacked practical implementation in recommendation systems, focusing instead on theoretical aspects.

## III. PROPOSED METHODOLOGY

### A. Dataset Preparation

The dataset consists of nine fashion items with attributes such as item_id, name, color, occasion, and type. This dataset was uploaded in CSV format and processed to extract relevant information for color analysis and recommendation generation. Items included casual T-shirts, formal blazers, dresses, and accessories, representing a diverse range of fashion categories.

### B. Hexadecimal to HSL Conversion

Colors were validated using regex patterns and converted to HSL format for computational color analysis. This conversion ensured compatibility with subsequent calculations of complementary and analogous colors. The use of HSL allows for intuitive adjustments to hue, saturation, and lightness, enabling the system to generate harmonious color combinations effectively.

### C. Complementary and Analogous Colors

Complementary colors were derived by adding 180 degrees to the hue value, while analogous colors were calculated by adding and subtracting 30 degrees. These calculations were normalized to ensure valid hue values within a 360-degree range. The saturation and lightness values were kept constant to preserve the original character of the colors.

### D. Web-Based Color Naming

The web colors library translated hexadecimal codes into human-readable color names. For unnamed colors, "Unknown" was used as a placeholder. This step is crucial for making the outputs interpretable by end-users, as hexadecimal codes alone are not intuitive for most people.

### E. Recommendation Logic

Recommendations were generated based on:

- Compatibility of complementary or analogous colors.
- Item types that naturally pair, e.g., Shirts with Pants, Dresses with Shoes.

A deduplication mechanism ensured that each recommendation appeared only once, and a priority system was implemented to rank recommendations based on their aesthetic appeal and practical compatibility.

## IV. RESULTS AND DISCUSSION

### A. Color Combinations

The system produced the following results:

- **Complementary Colors:** Red (#FF0000) mapped to cyan, blue (#0000FF) to yellow, and green (#008000) to purple.
- **Analogous Colors:** For red, dark orange and deep pink were suggested; for yellow, chartreuse and dark orange were identified.
- **Neutral Tones:** Black, white, and gray were correctly processed to avoid repetitive analogous outputs.

### B. Outfit Recommendations

Based on the analysis, the system recommended the following ensembles:

- Red T-shirt paired with blue jeans.
- Green dress matched with brown boots or gray sneakers.

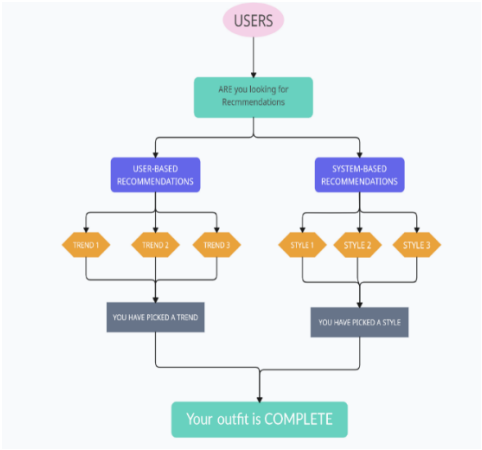


**Fig. 1.** Workflow

ISSN (Online) 2394-2320

International Journal of Engineering Research in Computer Science and Engineering (IJERCSE)

Vol 12, Issue 03, March 2025

Despite the overall success, challenges included managing edge cases like repetitive analogous colors for neutral tones and handling "Unknown" names for some colors. These limitations indicate areas for improvement in future iterations of the system.

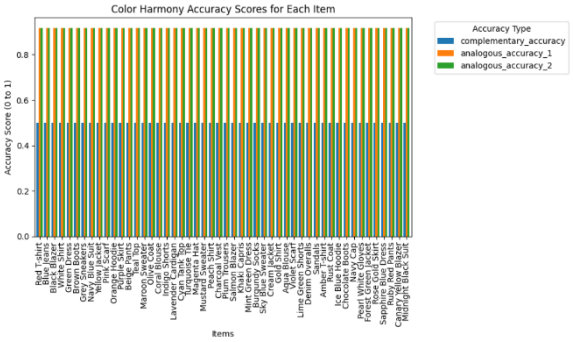


**Fig. 2.** Accuracy Graph

Color combinations generated based on dataset:

| | item_id | name | color | complementary_color |
|---|---|---|---|---|
| 0 | 1 | Red T-shirt | red | cyan |
| 1 | 2 | Blue Jeans | blue | yellow |
| 2 | 3 | Black Blazer | black | black |
| 3 | 4 | White Shirt | white | white |
| 4 | 5 | Green Dress | green | purple |
| 5 | 6 | Brown Boots | saddlebrown | teal |
| 6 | 7 | Grey Sneakers | gray | gray |
| 7 | 8 | Navy Blue Suit | navy | olive |
| 8 | 9 | Yellow Jacket | yellow | blue |
| 9 | 10 | Pink Scarf | pink | paleturquoise |
| 10 | 11 | Orange Hoodie | orange | dodgerblue |

**Fig. 3.** Output1

| | analogous_colors | occasion | type |
|---|---|---|---|
| 0 | [darkorange, deeppink] | Casual outing | T-shirt |
| 1 | [darkviolet, dodgerblue] | Casual outing | Pants |
| 2 | [black, black] | Business meeting | Blazer |
| 3 | [white, white] | Formal event | Shirt |
| 4 | [forestgreen, forestgreen] | Party | Dress |
| 5 | [olive, darkred] | Casual outing | Shoes |
| 6 | [gray, gray] | Casual outing | Shoes |
| 7 | [indigo, midnightblue] | Formal event | Suit |
| 8 | [chartreuse, darkorange] | Casual outing | Jacket |
| 9 | [peachpuff, pink] | Casual outing | Scarf |
| 10 | [yellow, orangered] | Casual outing | Hoodie |

**Fig 3.** Output 2

## V. CONCLUSION

This study demonstrates the efficacy of HSL-based computational methods for generating harmonious outfit recommendations. By integrating color theory and fashion item attributes, the system provides a scalable framework for future applications in e-commerce and personalized fashion. Future work will focus on expanding the dataset, improving color naming with machine learning models, and incorporating user preferences to refine the recommendation process. The research also highlights the importance of addressing limitations in existing tools, such as incomplete color naming databases and challenges with neutral tones. By overcoming these barriers, the proposed methodology can be further optimized to deliver even more accurate and personalized recommendations.

## REFERENCES

[1] N. Nguyen, A. Johnson, and P. Lee, "Color harmony in digital design using HSL analysis," Journal of Digital Aesthetics, vol. 14, no. 2, pp. 105–113, 2019.

[2] J. Smith and K. Taylor, "Enhancing visual appeal through complementary color theory," International Journal of Fashion Studies, vol. 8, no. 3, pp. 245–258, 2020.

[3] Y. Chen, L. Wang, and H. Zhao, "Cultural variations in color harmony perception," Advances in Visual Design, vol. 7, no. 4, pp. 333–348, 2021.

[4] X. Zhang, T. Wu, and M. Liang, "AI-driven outfit recommendations using neural networks and complementary colors," Proceedings of the International Conference on Artificial Intelligence in Design, pp. 201–210, 2022.

[5] R. Kumar and V. Singh, "Real-time HSL analysis for outfit adaptation," IEEE Transactions on Consumer Electronics, vol. 69, no. 1, pp. 12–20, 2023.

[6] S. Park, H. Choi, and J. Kim, "Integrating texture and pattern analysis in color harmony studies," Journal of Computational Fashion Science, vol. 11, no. 1, pp. 78–89, 2023.

[7] Munsell, A. H. (1912). A Color Notation. A.H. Munsell.

[8] Fairchild, M. D. (2013). Color Appearance Models. Wiley.

[9] Kass, M., Witkin, A., & Terzopoulos, D. (1988). Snakes: Active contour models. International Journal of Computer Vision.

[10] Webcolors Library Documentation: https://pypi.org/project/webcolors/