



A Hybrid Multi-Objective Colour Recommendation Framework for Interior Wall Painting Using NSGA-II and Retail Service Integration

Prof. Anjali Yeldi¹, Amit Rampratap Vishwakarma², Vivek Kumar Sahni³, Tattapure Shantling Bhimashankar⁴

anjaliyeldi@gmail.com , v2003amit@gmail.com , viveksahni2087@gmail.com
shantlingtattapure@gmail.com

¹Project Guide, ²MCA Student, ³MCA Student, ⁴MCA Student
 ASM's Institute of Business Management and Research, Pune, Maharashtra, India

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Abstract: - Selecting interior wall paint involves multiple conflicting objectives such as aesthetic colour harmony, material cost, and vendor reliability. Traditional e-commerce platforms offer fragmented services and lack integrated visualization or professional painter booking. Earlier research works

mainly focused on Interactive Genetic Algorithms and automated material suggestion for 3D indoor scenes, but they did not combine colour optimization with real-world retail logistics and on-demand labour services. This paper presents a hybrid Multi-Objective Colour Recommendation System that bridges this gap. The proposed system integrates a Zomato-style paint delivery model, an Urban Company-style painter booking model, and a Policy Bazaar-style multi-brand comparison approach. Using K-Means clustering for dominant colour extraction from room photographs and NSGA-II for multi-objective optimization, the system generates Pareto-optimal recommendations that simultaneously balance colour harmony, cost, and vendor reliability.

Keywords: Multi-Objective Optimization, NSGA-II, K-Means Clustering, Colour Recommendation, E-Commerce Integration, Pareto Front.

Introduction

Interior colour selection has a significant impact on the comfort and appearance of living spaces. Traditionally, homeowners depend on static colour cards available at retail stores or take decisions based on personal preference. With the growth of digital platforms, users now expect solutions that allow them to visualize colours in their own rooms, compare prices across brands, and book professional painters easily.



Most existing research has focused only on aesthetic optimization or 3D scene generation. Similarly, current commercial platforms either sell paint or provide painting services, but do not offer intelligent multi-objective recommendations. There is a clear need for a unified system that can perform colour recommendation, material estimation, multi-vendor comparison, and service booking together.

This paper proposes a complete web-based platform developed using Python (FastAPI) and React that solves the above problem through multi-objective optimization and practical service integration.

I. Review Methodology

This Study follows a narrative review approach. Research papers related to colour harmony, evolutionary algorithms, interior design automation, and e-commerce integration were reviewed.

The Selected studies were analysed based on their optimization objectives, type of data used, and level of commercial integration. The main aim was to identify the gaps between academic colour recommendation systems and real-world retail execution.

II. Concept of the Proposed Framework

The Proposed platform is a two-sided digital marketplace that connects customers, paint vendors, and painters.

Users can upload room photographs, set preferences and budget, and receive optimized colour recommendations.

The System uses a multi-objective optimization engine to generate trade-off solutions instead of a single recommendation.

Vendors manage their product listings and inventory, while painters can receive and accept service bookings.

III. Digital Services and Core Technologies

The Platform combines three service models:

- Zomato-style model for paint material delivery from local vendors
- Urban Company-style model for on-demand painter booking
- Policy Bazaar-style model for multi-brand price and feature comparison

The Core technologies used are K-Means clustering for extracting dominant wall colours, CIEDE2000 for measuring perceptual colour difference, and NSGA-II for generating Pareto-optimal solutions. The system is developed using React.js for the frontend and FastAPI for the backend.

IV. Platform Architecture and Service Flow

The system architecture consists of the following main modules: Room Capture and Visualization, Material Estimation, Multi-Objective Recommendation Engine, Vendor Aggregation, E-Commerce Checkout, Painter Booking, Order Tracking, and Feedback Management.

Workflow:

1. User uploads a room photograph and selects preferences.
2. System extracts dominant colours using K-Means clustering.
3. NSGA-II optimizes three objectives – colour harmony, cost, and vendor reliability.
4. User is shown Pareto-optimal options (Best Colour Match, Best Value, Highest Reliability).
5. User selects an option, purchases paint, and optionally books a painter.
6. After service completion, feedback is collected to improve future recommendations.

V. Applications

The Platform can be used by individual homeowners for renovation planning, interior designers for client



presentations, paint dealers for receiving online orders, and painting contractors for getting verified job leads.

VI. Benefits

- Provides multiple trade-off options instead of one fixed recommendation
- Saves user time by combining visualization, comparison, purchase and service booking
- Improves decision quality through multi-objective optimization
- Continuously learns from user feedback
- Reduces dependence on physical colour cards and manual vendor search.
- It bridges the gap between software algorithms and real-world commercial workflows.

VII. Challenges and Limitations

- Colour extraction accuracy depends on the lighting condition of uploaded photos
- Real-time inventory integration from multiple vendors is complex
- Browser-based visualization has device performance limitations
- New vendors and painters face cold-start issues due to lack of ratings

VIII. Comparative Analysis of Digital Services

Feature	Previous Academic Systems	Commercial Paint/Service Apps	Proposed System
Colour Harmony Optimization	Yes	Limited	Yes (CIEDE2000)
Multi-Objective Optimization	Rarely	No	Yes (Colour + Cost + Reliability)
Live Multi-Vendor Comparison	No	Partial	Yes

Paint Material Delivery	No	Yes	Yes
Painter Service Booking	No	Yes	Yes
Pareto Trade-off Presentation	No	No	Yes
Closed-loop Feedback	Rare	Limited	Yes
End-to-End Execution Support	No	Partial	Yes

The Table shows that the proposed system uniquely combines algorithmic multi-objective optimization with complete retail and service integration.

IX. Research Gaps

Most earlier studies optimized only aesthetic factors and operated on closed synthetic catalogues. Very few works considered live pricing, stock availability, and vendor reliability together. Presenting results as understandable Pareto trade-offs for non-expert users and implementing a closed feedback loop from real service execution remain important research gaps. This paper directly addresses these gaps.

X. Future Scope

Future work includes real-time AR wall colour preview, live inventory APIs from major paint brands, native mobile applications, and extension of the framework to full interior design elements beyond wall paint.

XI. Discussion

The Proposed framework successfully links academic multi-objective optimization research with practical commercial needs. By generating Pareto-optimal solutions and supporting end-to-end execution, the system offers greater transparency and usefulness



compared to traditional single-score recommendation approaches.

XII. Conclusion

This Paper presented a hybrid multi-objective colour recommendation framework that integrates NSGA-II optimization with multi-brand comparison, paint delivery, and painter booking. The system overcomes key limitations of earlier research by simultaneously considering colour harmony, cost, and vendor reliability while providing a complete user journey from room photograph to service completion.

XIII. Acknowledgment

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