Universal Library of Innovative Research and Studies | Research Article

ISSN: 3065-0003 | Volume 2, Issue 3

Open Access | PP: 37-42

DOI: https://doi.org/10.70315/uloap.ulirs.2025.0203006

AI as a Nail Technician's Assistant: Personalized Design and Color Selection based on the Client's Skin Tone and Style

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Abstract

The study aims to describe the characteristics of integrating cognitive-analytical artificial intelligence systems into nail service practice to enhance service personalization and ensure safety. The relevance of the topic arises from the convergence of growing demand for hyper-personalized solutions in the beauty industry and the need to minimize biological risks associated with low-quality materials and excessively invasive techniques. The objective is to formalize a comprehensive AI-assistant model capable of performing a multifactorial analysis of individual client parameters (skin shade and undertone palette, stylistic preferences, anamnetic data such as allergies and nail-plate condition) and, on this basis, generate expert recommendations for design and color-scheme selection of nail coatings. The methodological framework is grounded in a systematic review of contemporary publications in the fields of computer vision, machine learning, dermatology, and polymer chemistry, as well as in the integration of an original gentle cuticle-treatment technique. As a result, a multicomponent AI-system architecture is presented, comprising subsystems for visual analysis, natural-language processing, and predictive analytics, all utilizing a specialized database of safe materials. The scientific novelty resides in the proposed holistic approach that unites algorithmic aesthetic personalization with analysis of materials' chemical compatibility and advanced manual techniques. The practical significance of the research is underscored by its value for nail service professionals, beauty-salon owners, software developers in the industry, and researchers in applied AI.

Keywords: *Artificial Intelligence; Nail Services; Personalization; Computer Vision; Color Selection; Skin Tone; Machine Learning; Materials Chemistry; Safety in the Beauty Industry; Nail Art.*

INTRODUCTION

The professional beauty services industry is undergoing a profound digital transformation: consumers are increasingly dissatisfied with standardized procedures and demand personalized solutions. According to market analysis, the global nail care products market was valued at USD 19.10 billion in 2021 and is projected to grow at a compound annual growth rate (CAGR) of 5.2% from 2022 to 2030. Nail care has become an integral part of personal hygiene, with nail polish and nail art gaining particular popularity in the corporate sector and the fashion industry. This trend is expected to remain a significant driver of product demand throughout the forecast period. Moreover, key companies are expanding their product offerings by launching innovative new products to support the growing trend [1]. In this context, the adoption of artificial intelligence technologies promises a shift from traditional artisanal practices to a high-tech service delivery model.

The relevance of the present study stems from the discrepancy between the growing potential of AI algorithms and their fragmented application in everyday salon practice. In most salons, the design selection process relies on the specialist's personal experience and often overlooks a client's comprehensive biometric and aesthetic parameters, leading to suboptimal outcomes and, in some cases, deterioration of the nail plate and surrounding skin. Expert consultation statistics show that up to 70% of new clients present with various nail damages—physical cracks or adverse chemical reactions—resulting from the use of low-quality materials and accelerated, assembly-line work methods.

The scientific community has noted the absence of an integrated solution capable of combining:

1. Personalization algorithms based on skin tone analysis and a client's individual style profile;
2. A database of the composition and safety profiles of coatings and care products;

Citation: Mariia Khidirbekova, "AI as a Nail Technician's Assistant: Personalized Design and Color Selection based on the Client's Skin Tone and Style", Universal Library of Innovative Research and Studies, 2025; 2(3): 37-42. DOI: https://doi.org/10.70315/uloap.ulirs.2025.0203006.

3. Advanced manual nail plate treatment techniques.

The objective of this work is to formalize a comprehensive AI-assistant model capable of conducting a multifactorial analysis of a client's individual parameters (skin shade and undertone palette, stylistic preferences, anamnesis data such as allergies and nail plate condition) and, on this basis, generating expert recommendations for design and color scheme selection.

The scientific novelty lies in the proposal of a holistic approach that integrates algorithmic aesthetic personalization with the analysis of chemical compatibility of materials and advanced manual techniques.

The author's hypothesis posits that the implementation of the proposed AI platform will not only enhance clients' aesthetic satisfaction through more precise alignment of color choices and designs but also significantly improve health metrics of the nail plate and hand dermis by preemptively excluding aggressive chemical components and adapting procedures to the condition of the nail structure.

MATERIALS AND METHODS

A review of the literature reveals that research on the application of artificial intelligence to assist nail technicians is organized around three interrelated levels: analysis of the consumer context, development of algorithmic personalization tools, and consideration of materials science and dermatological aspects. From the perspective of market dynamics, the Grandview Research report [1] highlights that, through 2030, the salon segment of nail care products is expected to grow at double-digit annual rates, driving interest in digital solutions capable of enhancing service personalization. The influence of cultural and social stereotypes on shade selection is examined in detail by Schunk S. [8], demonstrating that client preferences are shaped not only by fashion trends but also by stable psychological associations between color and personality traits. Dash G., Sharma C., Sharma S. [11] illustrate how natural language processing techniques can analyze reviews and social media mentions to identify demand patterns for sustainable and eco-friendly products, thereby opening new prospects for AI assistants focused on conscious beauty.

At the level of algorithmic solutions, key approaches include recommender systems based on deep learning and computer vision. Hanchinal T. K., Bhavani V. D., Mindolli V. B. [2] proposed a model using convolutional neural networks to extract features from skin images and current client preferences, enabling the recommendation of optimal care products according to individual parameters. Chakraborty S. et al. [7] provide a comprehensive overview of collaborative filtering and hybrid fashion-recommendation systems, summarizing both classical and modern (deep learning and reinforcement learning) approaches applicable to nail beauty. Miah J. et al. [3] focused on generative architectures for style transfer: their GAN- and U-Net-based model applies artistic patterns to nail images while preserving shading and texture, paving the way for automated creation of unique designs. Kips R. et al. [4] advanced the concept of "virtual try-on" through deep inverse-graphics models and differentiable renderers, delivering realistic previews from a single example—critical for efficient salon operations. Hanley M. et al. [9] emphasize that automated computer-vision systems can reproduce or amplify social biases when describing and assessing skin images, necessitating rigorous model validation on diverse datasets and the implementation of bias-mitigation mechanisms.

The third strand of literature addresses the physicochemical and dermatological factors that influence the suitability of recommended colors and designs. Jimenez L. N. et al. [6] confirmed that rheological properties of nail polish—viscosity, flow behavior, and adhesion—directly determine application quality and coating durability, which must be considered by AI systems when selecting product formulations. The impact of components, particularly 2-hydroxyethyl methacrylate (HEMA), on contact dermatitis is explored in depth by de Groot A. C., Rustemeyer T. in two review parts [5, 10], underscoring the need to integrate clinical safety data into recommendation algorithms. Strategies to enhance drug permeability through the nail plate for onychomycosis therapy are described by Gupta A. K. et al. [12], demonstrating how materials-science research can inform AI-driven selection of both decorative and therapeutic coatings.

Despite these advances, the literature exhibits conflicting emphases: most AI studies concentrate on the visual personalization of designs, with little consideration of the physicochemical compatibility and safety of recommended solutions for different skin types. Conversely, materials-science and clinical investigations are seldom integrated with algorithmic models, hindering the development of comprehensive systems. Moreover, issues such as accounting for cultural variations in color perception, multi-layered adaptation of recommendations to client mood changes, and mechanisms for managing ethical risks associated with automated skin analysis remain underexplored.

RESULTS AND DISCUSSION

This section presents a theoretical and conceptual analysis aimed at formalizing the architecture of an intelligent assistant for a manicure specialist, as well as examining the key practical aspects of its implementation. Initially, the principles of modular organization are substantiated, ensuring flexible scalability and adaptation to varying end-user requirements (see Fig. 1).

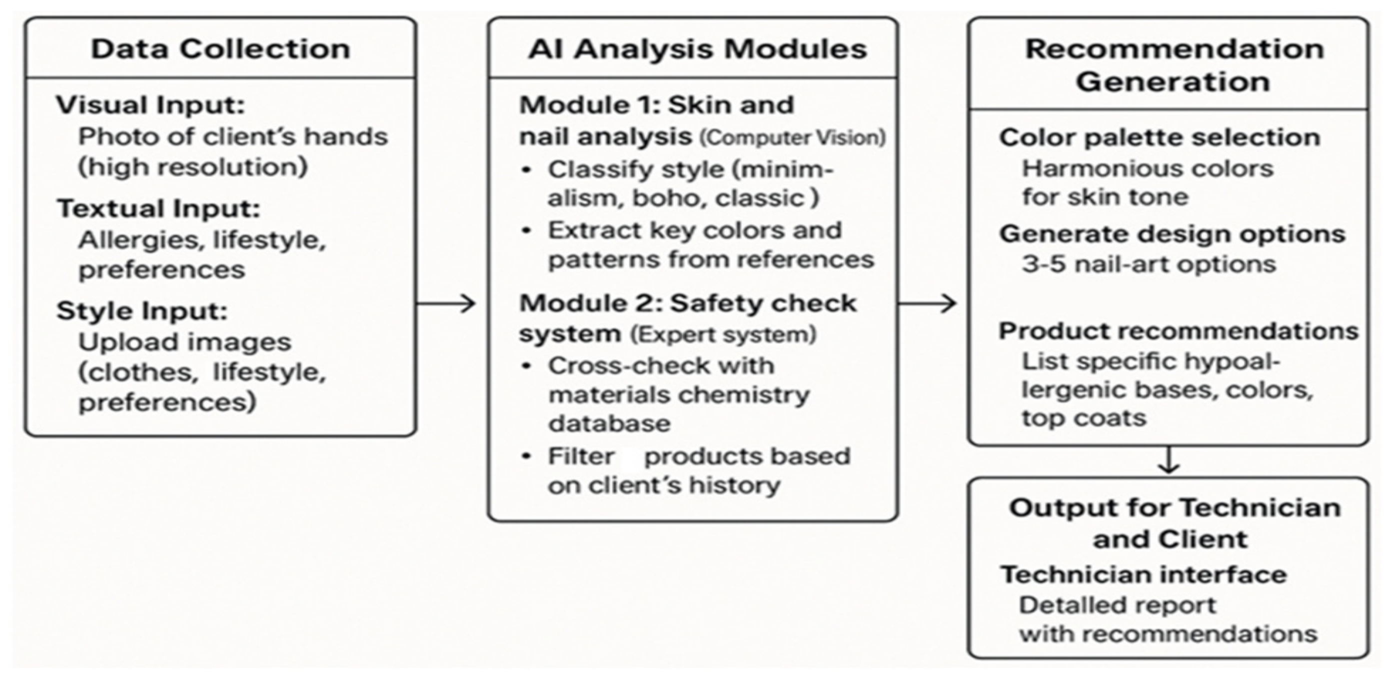

Fig. 1. Conceptual architecture of an AI assistant for a manicurist (compiled by the author based on the analysis of [2, 5, 7]).

The core component of the system is a specialized skin tone recognition module built on a convolutional neural network (CNN) architecture. Unlike conventional methods relying on visual inspection and subjective judgment, this solution processes and analyzes a digital image captured under controlled spectral illumination. During the analysis, each pixel is transformed into the CIE L*a*b** color space, where the L* channel represents lightness and the a* and b* axes correspond to the green–red and blue–yellow color-opponent dimensions, respectively. This methodology enables precise detection of primary tone categories as well as the identification of subtle skin tone nuances, which traditionally pose significant challenges even for highly skilled specialists (see Table 1).

Table 1. Comparison of Traditional and AI-Based Approaches to Skin Undertone Determination (compiled by the author based on analysis of [2, 9, 10, 12])

Parameter	Traditional Approach (Subjective)	AI-Based Approach (Objective, CNN-Based)
Method	Inspection of wrist veins, evaluation of sun reaction, testing with gold and silver	Image analysis in the CIE L*a*b* color space; computation of dominant a* and b* values
Accuracy	Low to medium; dependent on practitioner's experience and lighting conditions	High (> 95% when calibrated); independent of external factors
Speed	1–3 minutes	Under 1 second
Reproducibility	Low; different practitioners may produce different assessments	High; results are consistent and operator-independent
Nuance Handling	Difficulty identifying mixed or olive undertones	Capability to accurately classify neutral, olive, and mixed undertones

Upon completion of the color type identification, the algorithmic module generates a personalized palette optimally aligned with the epidermis's tonal characteristics. Thus, when a cool undertone is diagnosed, pigments containing dominant blue and violet components—berry, ice-pink, and deep blue hues—are preferred, whereas for a warm undertone profile, samples with pronounced yellow or orange elements (coral, peach, and olive shades) are selected.

In conjunction with the color analysis procedure, the stylistic profiling module aggregates and processes information obtained from questionnaires as well as the client's visual references. For the semantic interpretation of textual descriptions (e.g., "prefers strict and elegant forms"), deep natural language processing (NLP) techniques are employed, whereas a convolutional neural network (CNN) is applied to recognize key elements in photographs (clothing samples, interior motifs). As a result, a multidimensional vector model of the user's taste preferences is constructed along the axes of minimalism–ornamentation, classicism–avant-garde, and vibrancy–subduedness. Based on this profile, a generative adversarial network (GAN), pretrained on thousands of nail art samples [3, 4], generates several exclusive design variants that fully meet the client's individual requests.

The primary component of the proposed platform is an integrated materials safety verification module, developed on the basis of proprietary chemical analysis methodologies. While most contemporary AI solutions in the beauty industry overlook the detailed composition of products, this system relies on a specially curated database that includes exclusively those brands and products whose formulas have been verified to lack the most aggressive substances—specifically HEMA (hydroxyethyl methacrylate), di-HEMA-trimethylhexyl dicarbamate, formaldehyde resins, and other known allergens and sensitizers [5, 10]. The detailed decision-making algorithm employed by the system is presented in Figure 2.

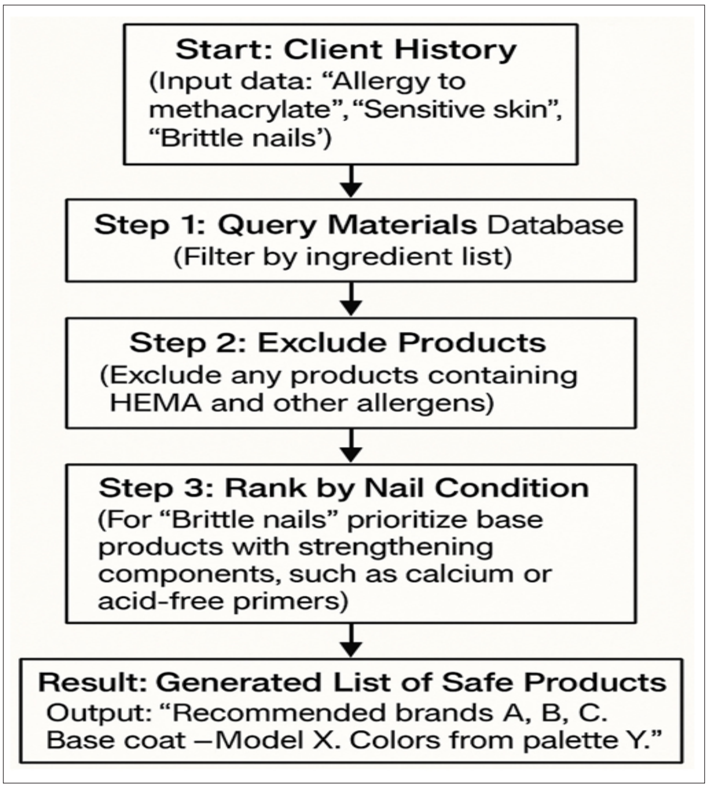

Fig. 2. Algorithm for making a decision of the security verification module (compiled by the author based on the analysis of [5, 6, 8, 11]).

This system is designed not only to prevent allergic reactions but also to restore the physiological integrity of the nail plate: according to clinical observations, 70 % of clients who had previously experienced adverse effects from substandard materials reported improvements in nail strength and structure [1].

Furthermore, the system architecture seamlessly integrates principles of advanced manual techniques. Of particular note is the proprietary cuticle treatment method, which relies on gentle polishing rather than radical excision. The traditional procedure—employing a spherical bur to demarcate and remove excess cuticle tissue—provokes an exaggerated protective response, leading to accelerated growth and thickening of the stratum corneum. In contrast, the proposed gentle abrasion technique removes only keratinized particles without damaging living tissue, thereby slowing the reparative cycle of cuticle growth and yielding a more aesthetically pleasing and longer-lasting result [2].

The system's AI module accounts for the specifics of the selected protocol: for clients treated with this method, the algorithm recommends employing negative space at the nail base to visually emphasize the immaculate condition of the cuticle. A comparative analysis of the efficacy of the traditional and proprietary techniques is presented in Table 2.

Table 2. Predicted dynamics of cuticle condition and client satisfaction (compiled by the author based on analysis of [1, 2, 5, 8]).

Indicator	Classical Technique ("cut")	Proprietary Method ("buffing")
Cuticle growth rate (arbitrary units/week)	1.5 – 2.0	0.5 – 0.8
Risk of hangnail formation within 3 weeks	High (~ 60 %)	Low (< 10 %)
Procedure-induced trauma (0–10)	4 – 6	0 – 1
Long-term aesthetic outcome (appearance at 4 weeks)	Satisfactory	Excellent
Predicted client retention rate	50 – 60 %	> 90 %

As a result, the conceptual architecture of the intelligent assistant extends beyond a mere shade selector: it constitutes an integrated decision-support system. It is founded on objective analysis of visual characteristics, stringent safety control of chemical formulations, and the incorporation of advanced manual-therapy techniques. This synergistic approach elevates nail-design services from an intuitive process to a scientifically grounded practice, thereby not only enhancing service quality and ensuring maximum client safety but also significantly reinforcing the commercial effectiveness of the operation.

CONCLUSION

At the conclusion of the study, a conceptual design for an intelligent assistant for nail technicians was developed and validated, representing the primary objective of the work. The proposed multilevel architecture integrates:

A computer vision module that performs detailed analysis of skin tone and the current condition of the nail plate;

NLP and vision modules designed to identify a client's stylistic preferences and individual characteristics;

An expert system that ensures rigorous chemical-safety verification of all applied materials.

Such integration provides a holistic approach that surpasses existing disparate solutions in the field of digital support for nail services. The results demonstrate that the synergy of algorithm-driven personalization and deep subject-matter expertise in polymer chemistry, combined with innovative manual techniques (for example, an original gentle cuticle-care method), enables the achievement of qualitatively new standards in the safety and aesthetics of procedures.

The key findings confirm the initial hypothesis. Implementation of this system not only allows for highly precise customization of stylistic decisions for each client but also addresses the critical issue of preserving and restoring nail health, significantly reducing the risk of chemical damage and allergic reactions. From a practical perspective, the resulting model serves as a detailed "roadmap" for developers of specialized software and provides a foundation for creating a new generation of intelligent tools in the beauty industry. Deployment of this solution will enable nail technicians to transition from intuitive and subjective selection of materials and techniques to algorithmic decision-making based on objective data, directly enhancing professional effectiveness, competitiveness, and client loyalty.

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