

Perfect Blend - Custom Foundation Matching for South Indian Skin Tone

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Abstract - The project "Perfect Blend: Custom Foundation Matching for South Indian Skin Tone" tackles the makeup industry's challenge of accurately matching foundation to individual skin tones. The project develops an innovative website that captures precise skin tones and generates corresponding color codes, focusing on the predominant color of the face while accounting for common discolorations like sun tans. By measuring facial dimensions and excluding areas such as the beard, eyebrows, and lips, the website determines the exact amount of foundation needed, optimizing product usage and minimizing waste. Future enhancements aim to enable the mixing of custom foundation shades, specifically addressing the unique skin tones of individuals in South India. This approach ensures a more reliable and inclusive solution for foundation matching, catering to the diverse beauty needs of the region.

Key Words: Custom Foundation Matching, Skin Tone Detection, Color Code Generation, Haar Cascade Classifier, K-Means Clustering

I. INTRODUCTION

The cosmetics industry has made considerable progress in recent years toward embracing diversity and inclusivity. However, a significant gap still remains, particularly when it comes to catering to the nuanced and diverse skin tones of South Indian individuals. Recognizing this persistent issue, we propose an innovative solution titled "Perfect Blend – Custom Foundation Matching for South Indian Skin Tone." This project is specifically designed to bridge the gap between consumer needs and product availability with the help of advanced technology. The main goal of "Perfect Blend" is to provide a data driven, intelligent, and highly personalized approach to foundation matching. Unlike conventional methods that offer limited shade ranges and force users to serve as a reliable reference point for foundation matching. But accurate shade detection is only part of the solution. To further enhance the customization process, our system also measures the

dimensions of the user's face directly from the input image. This allows us to estimate the surface area to be covered with foundation, which in turn enables precise calculation of the total quantity of product needed. By combining this data with the identified target shade, the system calculates the optimal ratio of three predefined base foundation shades, lightest, medium, and darkest, available within any given makeup brand. The result is a personalized blend recommendation that is both efficient and accurate. This innovative fusion of computer vision, artificial intelligence, and cosmetic science offers a groundbreaking solution to one of the most persistent issues in beauty and personal care. By automating and personalizing the process of foundation selection and mixing, "Perfect Blend" not only saves time but also reduces human error and minimizes product waste. It uses image analysis to detect the user's precise skin tone, intelligently matches it with an optimal foundation shade, and does not enable on-the-spot blending to achieve a custom formulation tailored to the individual. This not only saves valuable time for both consumers and beauty professionals but also reduces human error and minimizes the excess usage of cosmetic products. As a result, it enhances customer satisfaction, promotes sustainability by cutting down on product waste, and sets a new standard for efficiency and inclusivity in the cosmetic industry. Ultimately, this project is about more than just convenience - it's about inclusivity, confidence, and empowering users with tools that respect the uniqueness of their skin. By delivering precision and personalization at scale, "Perfect Blend" redefines the foundation matching experience for South Indian skin tones, turning a traditionally subjective process into a reliable and repeatable system that elevates both professional artistry application. By and everyday makeup delivering precision and personalization at scale, this project transforms what has traditionally been a subjective, trial-and-error experience into a data-backed, reliable, and repeatable system. It ensures

that every user, regardless of their complexion, has access to foundation shades that truly match their skin, enhancing not just appearance but also self-assurance and satisfaction

II. LITERATURE REVIEW

Nemli et.al [1] (2018) evaluated color and translucency matching of maxillofacial prostheses using Delta-E. Their research addressed the critical need for accurate color matching in prosthetic devices, ensuring that prostheses closely resembled natural tissues. By using Delta-E, they provided a quantitative measure for assessing color differences, contributing to the development of more realistic and aesthetically pleasing prosthetic solutions. This study was significant for advancing medical prosthetics and improving patient outcomes.

Ruiz-López et.al [2] (2022) assessed color differences between natural teeth and dental implants using Delta-E. Their study aimed to ensure that dental implants matched the color of natural teeth, which is crucial for patient satisfaction and aesthetic outcomes. By applying Delta-E, they were able to quantify color differences and improve the accuracy of color matching processes. This research demonstrated the importance of precise color measurement in dental applications, contributing to better integration of implants with natural teeth.

Hussain et.al [3] (2019) used the HSV color model to identify skin-colored pixels by setting threshold values for the H channel. Their approach highlighted the effectiveness of HSV in distinguishing skin tones from other colors, making it suitable for applications like facial recognition. By setting specific threshold values, they were able to enhance the accuracy of skin detection, even in varied lighting conditions. This study provided valuable insights into the practical applications of HSV in real-world scenarios.

Li et.al [4] (2020) applied YCrCb color space and a two-dimensional Gaussian model for skin color detection, noting its robustness against external brightness. Their method achieves superior performance in maintaining accuracy despite changes in lighting, making it ideal for outdoor and dynamic environments. By combining YCrCb with a Gaussian model, they achieved a reliable skin detection system that could be applied to various fields, including surveillance and human-computer interaction.

Lumini et.al [5] (2020) compared pixel-based algorithms, spatial analysis, and deep learning for skin detection, highlighting the strengths and weaknesses of each approach. Their comprehensive comparison provided a clear understanding of the trade-offs involved in different methods, guiding researchers and practitioners in selecting the most appropriate technique for their needs. By evaluating both traditional and modern approaches, their study underscored the advancements and ongoing challenges in skin detection technologies.

Chen et al [6] (2022) proposed a technique for detecting GAN-generated fake faces using RGB and YCrCb color spaces along with an improved Exception technique. Their innovative approach addressed the growing concern of deepfake detection, providing a reliable method for distinguishing real faces from artificially generated ones.

Kolkur et.al [7] (2017) developed a threshold-based algorithm using RGB, HSV, and YCrCb color models for human skin detection. Their method considered various factors such as brightness and contrast, ensuring robust performance across different environments. By integrating multiple color models, they were able to enhance the flexibility and accuracy of their detection system. This research contributed to the development of versatile skin detection algorithms that can adapt to diverse conditions.

Buza et al. [8] (2018) proposed a hybrid skin detection method combining HSV and YCrCb colour spaces, histogram equalization, and Otsu's thresholding. Their multi-step approach involved normalizing illumination across images using histogram equalization, enhancing contrast for better. Otsu's method was applied afterward to separate skin pixels effectively. The dual use of HSV and YCrCb ensured robustness against varied lighting and ethnicity variations. Their experiments demonstrated that combining multiple pre-processing techniques significantly improves segmentation accuracy, reducing noise and false positives. This concept is critical for our project, where reliable skin tone extraction under non uniform lighting is a key requirement for accurate foundation matching.

Varma and Behera et.al [9] (2018) developed an integrated technique using histogram processing and a Gaussian model across HSV and YCrCb colour spaces to detect human skin. Their research showed

that by combining colour normalization (through histograms) and statistical modelling (through Gaussian distribution), the system achieved an outstanding 86% accuracy in skin detection across variable datasets. Their hybrid approach highlights the importance of blending both statistical and colour based methods to overcome challenges such as illumination variation and diverse skin tones, aligning perfectly with the demands of real-time foundation matching systems.

Hema and Kannan et.al [10] (2020) Hema and Kannan proposed a dynamic skin detection model for medical imaging applications, leveraging the HSV colour space. They introduced adjustable thresholding parameters that allow real-time tweaking based on different lighting conditions and skin shades. Their semi-automated system enhanced segmentation accuracy without requiring heavy computation, making it feasible for portable or web-based systems. Their dynamic thresholding concept is highly applicable to our project, where users may upload images under various lighting conditions, requiring flexible adaptation to accurately capture true skin tone for personalized foundation suggestions.

Mohammed et.al [11] (2020) evaluated the effectiveness of RGB and YCrCb colour spaces under different illumination settings. They found that YCrCb outperformed RGB by maintaining skin colour stability despite varying lighting intensities, shadows, or backgrounds. Their experiments demonstrated that separating luminance from chrominance significantly reduces the risk of misclassification in skin segmentation tasks. Their findings advocate the necessity of YCrCb or similar models for robust cosmetic shade matching, where lighting inconsistencies can otherwise lead to inaccurate recommendations.

Nikolskaia et.al [12] (2018) tackled ethnic diversity challenges in skin detection using HSV colour space combined with SLIC (Simple Linear Iterative Clustering) super pixel segmentation. By breaking images into super pixels before classification, they reduced false positives caused by non-skin elements like dark hair or shadows. Their system was tested on multicultural datasets, showing superior accuracy for dark and light skin tones alike. Their method validates the need for advanced segmentation strategies.

3. PROPOSED SYSTEM

The paper proposes a user-friendly and innovative website dedicated to personalized foundation shade matching and recommendations, specifically tailored to meet the diverse and unique skin tones of South Indian individuals. This platform allows users to easily upload facial images, after which our advanced system processes the image to detect the most accurate and lightest natural skin tone of the individual, while also measuring essential facial dimensions. This analysis is key in identifying the precise undertones and color variations of the skin, allowing the system to recommend a customized blend of foundation shades in the correct proportions. This ensures a perfect, seamless match, eliminating the guesswork often involved in choosing the right foundation. In addition to offering personalized shade recommendations, the website provides valuable insights into the user's skin tone, suggesting multiple shade combinations that complement their natural color. Furthermore, the platform estimates the exact amount of foundation required for full face coverage, optimizing product usage and minimizing waste. The website's clean and intuitive interface is designed to enhance the user experience, making the process of foundation selection not only more scientific but also more inclusive and personalized. By focusing on the specific challenges faced by South Indian users in finding a perfect match, our platform addresses the gap in the cosmetics industry, providing a solution that caters to the rich diversity of skin tones in the region. With its data-driven, thoughtful approach, the website ensures a more reliable, effective, and empowering foundation selection experience for users across South India.

Upon receiving the uploaded image, our system processes it using advanced techniques such as Haar Cascade classifiers for facial feature detection and K Means clustering for skin tone analysis. The system focuses on identifying the lightest natural areas of the face, avoiding regions affected by sun tans, shadows, or facial features like beards, eyebrows, and lips. It also measures key facial dimensions to understand the coverage area required. This multi-step analysis ensures that the foundation recommendation is based on the user's true natural skin tone, rather than temporary discolorations.

Following the skin tone and facial dimension analysis, the system generates a personalized foundation shade recommendation. Instead of

suggesting a single premade shade, it advises a customized blend of different foundation colors in precise proportions, ensuring a perfect match for the user's unique skin tone. Additionally, it provides an estimate of the quantity of foundation needed for full face coverage, helping users optimize product use and reduce waste. Detailed reports include skin tone insights, recommended product combinations, and practical instructions for shade mixing.

Our website prioritizes a seamless and engaging user experience through a clean, minimalistic design. By combining scientific image analysis with practical beauty solutions, the platform makes foundation selection more inclusive, reliable, and customized. It empowers South Indian users—often underrepresented in mainstream beauty products—to find their ideal foundation shades easily and confidently. Through this personalized approach, we aim to bridge the gap between beauty technology.

4. SYSTEM IMPLEMENTATION

The core algorithm of the system combines two powerful techniques, K-means clustering for skin tone analysis and the Haar cascade classifier for facial feature exclusion, to ensure highly accurate and personalized foundation matching. K-means clustering plays a crucial role in identifying the user's skin tone by grouping similar pixels in the uploaded image. This allows the system to determine the lightest and most accurate skin tone, even accounting for variations such as sun exposure or lighting changes. The algorithm clusters pixels based on their color intensities, enabling it to identify the skin's predominant hue, which forms the basis for recommending the ideal foundation shade. On the other hand, the Haar cascade classifier is used to detect and exclude non-facial areas, such as the beard, eyebrows, and lips, from the skin tone analysis. These areas, which often have different textures and colors compared to the skin, could distort the accuracy of the foundation match if included. By excluding these features, the system ensures that only the face's skin tone is considered in the calculation, delivering a more accurate and natural result. The integration of both these algorithms ensures a seamless and effective process, allowing the system to recommend the perfect foundation shade while also providing an estimate of the precise quantity of foundation needed for full coverage. This not only results in a more tailored solution for each individual's unique skin tone but

also minimizes product wastage, enhancing both the efficiency and personalization of the foundation matching process. Through this sophisticated approach, users are provided with an accurate, customized, and reliable foundation recommendation, making the makeup selection process more inclusive and scientifically driven. The core algorithm integrates k-means clustering for skin tone analysis and the Haar cascade classifier for facial feature exclusion, combining two powerful techniques to ensure accurate and reliable results in matching foundation to an individual's skin tone. This approach not only facilitates the precise identification of the skin tone but also ensures that the foundation is applied appropriately by excluding non-facial areas, such as the beard, eyebrows, and lips, from the calculation. Together, these algorithms work in harmony to deliver a personalized foundation shade recommendation along with accurate measurement of the required foundation quantity.

Image Acquisition: The first and one of the most crucial steps in the foundation matching process is the acquisition of a high-resolution image of the individual's face. A clear and detailed image serves as the foundation for all subsequent analysis stages. To maintain consistency in data collection, the image must be captured under a standardized setup. This includes using controlled lighting conditions to avoid shadows, highlights, and color distortions that could interfere with accurate skin tone detection. Ideally, neutral white lighting is recommended to prevent the image from being too warm or cool in tone. Additionally, maintaining consistent camera angles and distance from the subject ensures that facial features are proportionately captured without distortion. The individual should face the camera directly, with a neutral expression, and minimal makeup to avoid interference with the natural skin color. Backgrounds should be plain and non-reflective to ensure that external colors do not affect the image analysis. Special care must also be taken to ensure that areas of the face prone to variation, such as the forehead, cheeks, and jawline, are clearly visible and unobstructed by hair, glasses, or other accessories. **Preprocessing:** Once the image is captured, the next critical step in the process is preprocessing the image to prepare it for accurate analysis. Preprocessing is essential because it helps eliminate common issues that may arise from variations in lighting, noise, and irrelevant elements, ensuring that the face is the focus of the analysis. The preprocessing phase applies a combination of

techniques designed to normalize lighting conditions, remove noise, and enhance the clarity of the skin features, which are vital for precise skin tone extraction. The first task is to address any lighting inconsistencies. Often, even under controlled conditions, slight differences in the lighting angle or intensity can create shadows or highlights that distort the true appearance of the skin. To counteract this, the image may undergo illumination normalization where brightness and contrast levels are adjusted to create uniform lighting across the face. This ensures that the skin's natural tones are not altered by uneven lighting and provides a consistent baseline for analysis. Next, noise removal is an essential part of the preprocessing step. Real-world images often contain unwanted visual disturbances, such as graininess or artifacts caused by the camera sensor. These elements can interfere with accurate skin tone detection and should be eliminated.

Skin Tone Analysis Using K-Means Clustering: The heart of the skin tone analysis process lies in the application of K-means clustering, an effective technique that groups pixels with similar color characteristics to identify the lightest skin tone in an image. In this method, the preprocessed facial image is analyzed by the K-means algorithm, which divides the image into several clusters based on the pixel values corresponding to different shades of color. Each cluster represents a specific range of colors, and the algorithm iteratively refines these clusters to find the one that most accurately represents the overall skin tone. One of the strengths of K-means clustering is its ability to handle the natural diversity of skin tones, accounting for subtle variations in hue and intensity that often arise due to factors such as lighting conditions, skin discolorations like redness, dark spots, hyperpigmentation, and tan lines. These common variations are considered by the algorithm as it groups pixels with similar characteristics together, allowing it to adapt to the unique features of each individual's skin. The clustering process also helps to distinguish between different areas of the face, ensuring that the lightest skin tone is accurately extracted from the most representative regions of the face. By identifying the most prominent and consistent cluster, the algorithm ensures that the skin tone analysis reflects the true complexion of the individual, without being influenced by external factors or temporary discolorations. The resulting tone serves as the basis for recommending the perfect foundation match, making the process highly

personalized and precise while minimizing the risk of mismatches caused by environmental variables or skin inconsistencies. This approach not only enhances the accuracy of foundation recommendations but also ensures a more inclusive and reliable method for catering to diverse skin tones. **Preprocessed Image Analysis:** The next step involves analyzing the preprocessed image to identify the lightest skin tone. This step takes into account the variability in skin tones, including common discolorations such as redness or dark spots, by grouping similar pixel values and determining the most representative color cluster. The algorithm ensures that the identified tone accurately reflects the individual's natural skin color. **Facial Feature Exclusion Using Haar Cascade Classifier:** To ensure that only the relevant skin areas are considered, the system utilizes a Haar cascade classifier to detect and exclude facial features like the beard, eyebrows, and lips. These areas are generally not covered by the foundation, so their exclusion is critical to accurate foundation recommendations. The Haar cascade classifier is trained to detect the contours of these features, ensuring that only the skin area is included in the calculation of foundation quantity and tone. This exclusion step is key for ensuring that the analysis focuses purely on the skin. **Color Code Generation:** Once the dominant skin tone is identified through the K-means clustering algorithm, the next step involves generating a precise color code that corresponds to the identified skin tone. This color code is a unique numerical or hexadecimal representation of the skin tone that serves as a key reference for the system to recommend an appropriate foundation shade. The generated color code is then cross-referenced with a comprehensive database of available foundation shades, which includes a wide range of tones suited to various complexions. By mapping the detected skin tone to the database, the system is able to suggest the most suitable foundation product based on the exact match of the skin's color code. This ensures that the recommended foundation shade is carefully tailored to blend seamlessly with the individual's natural complexion. The use of a color code also helps to maintain consistency and precision across different users, enabling the system to provide personalized recommendations that cater to the unique needs of each person, regardless of skin tone variations. The ultimate goal is to ensure that the foundation not only matches the skin's color but also enhances its natural look, offering a smooth and flawless finish. This process eliminates the guesswork often involved in traditional foundation

selection, making the experience more scientific, reliable, and personalized.

Foundation Quantity Measurement: Foundation Quantity Measurement: The final step in the foundation matching process is Foundation Quantity Measurement, which focuses on determining the exact amount of foundation needed for even and flawless coverage. To achieve this, the system first analyzes the dimensions and surface area of the user's face by evaluating facial features such as shape, size, and contours. Using advanced image processing techniques, the system calculates the total area of the face that requires foundation application, considering factors like cheekbones, forehead, chin, and jawline. Based on these measurements, the system estimates the precise quantity of foundation required to achieve a natural, uniform coverage, ensuring that the amount recommended is neither excessive nor too little. This approach eliminates the trial-and-error method typically involved in choosing the right amount of foundation, making the process more efficient and cost-effective. By providing an accurate foundation quantity, the system helps prevent product wastage, contributing to a more sustainable and practical application. Additionally, this recommendation enhances the user experience by ensuring that the foundation is applied in just the right amount to achieve a seamless finish, perfectly blending with the skin tone for a smooth, flawless look. This final step ensures that users not only receive a customized foundation shade but also a realistic and practical solution for foundation application that suits their specific needs.

The flowchart outlines it displays the actions that are necessary to meet the goals of a particular task in the most practical sequence. The system takes an input image. The received image data undergoes a pre-processing step. In the collected dataset, all the images have RGB coefficients in the range of 0-255 and different dimensions. Therefore, image rescaling and resizing are done. Next, transforming raw data into numerical features that can be processed while preserving the information in the original dataset is performed. This process is referred to as clustering. It yields better results than applying machine learning directly to the raw data. Here, we use a clustering algorithm such as K-Means to identify the predominant skin tone in the image. After the clustering step, the target output is generated. The output for the input image includes a color code representing the detected skin tone or the quantity of foundation required. This ensures the system accurately detects and quantifies the skin tone for practical cosmetic applications.

6 RESULTS

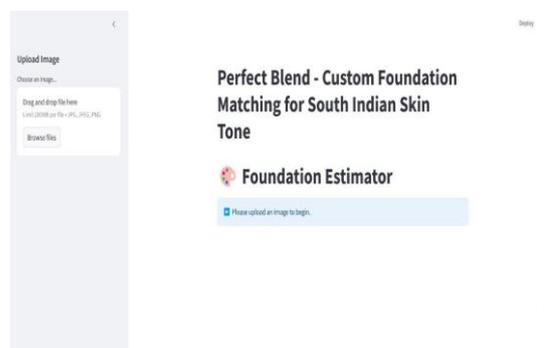


Figure -2: User Interface

5. SYSTEM DESIGN

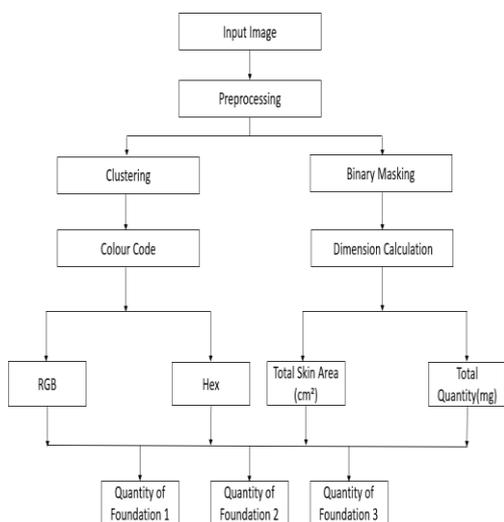


Figure -1: Flowchart Diagram of Model

Figure 3 below showcases that an image has been successfully uploaded and the skin tone has been extracted from it.

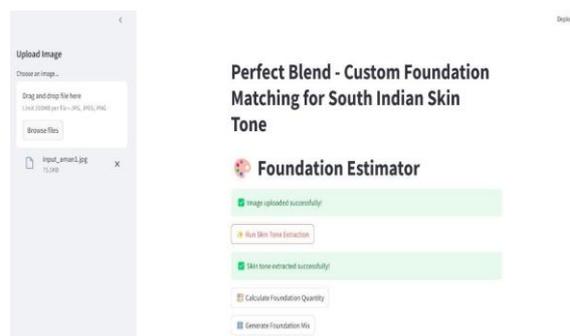


Figure -3: Skin Tone Extraction from Uploaded Image

Figure 4 below shows that the face and skin tone of the uploaded image have been successfully detected.



Figure -4: Face and Skin Tone Detection

Figure 5 below shows how much of each shade needs to be added.

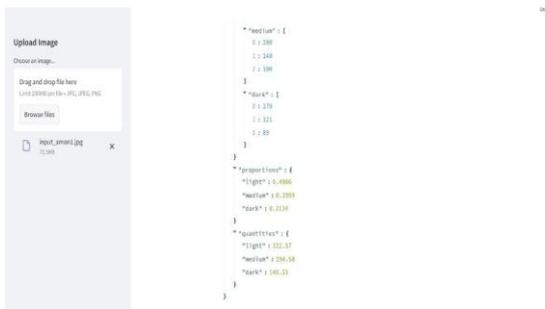


Figure -5: Shade Quantity Recommendation

7. CONCLUSIONS

This paper presents an innovative and inclusive approach to one of the most persistent and often overlooked challenges in the cosmetics industry achieving a perfect foundation match for diverse and underrepresented skin tones, with a particular focus on South Indian complexions. While there has been increasing awareness and efforts toward embracing diversity in beauty products, the market still lacks effective and targeted solutions that accurately cater to the broad spectrum of South Indian skin shades. Despite the rise of beauty inclusivity, mainstream foundation lines tend to generalize deeper skin tones into a limited and uniform range, often failing to recognize the subtle yet significant variations in undertones, pigmentation, and skin behavior typical of individuals from this region. These generalizations lead to the widespread issue of mismatched shades, where consumers are left struggling to find the right product for their unique skin tones. South Indian skin tones, with their distinctive undertones and varying degrees of melanin, often fall outside the scope of what current foundation lines offer, leaving individuals with few reliable options.

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