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Original Article

Dress Selection and Skintone Matching Tool

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Abstract: *As humans how we dress and mix colors together is a great factor in our style this can really determine ow attractive we will be seen and lastly the confidence will come into play. Still, most people struggle to identify what color suit they have and their skin feel resting on a hunch or vague premise. One such service is the Dress Selection and Skintone Matching Tool presented in this research, which a mobile application provides by analyzing the skin tone of user in order to suggest suitable colors from among different items of clothes. We then use a state-of-the-art image processing algorithm to process the facial images where the input data is in pixel values (color values of skin) and translated into perceptually uniform color spaces like CIE Lab* to classify the skin undertone as warm, cool or neutral based on pixel color value. Dress colors are matched with a database of curated fashion-appropriate shades that also follow traditional color theory, which guarantees the user the best look. Moreover, the system also meant using a conservation rule–based recommendation algorithm to make it more fine-grained in effect for the User God. Trialing it on 200 participants, test items agreed with professional stylist evaluations at a rate of 85% when it came to recommendations. Results — spikes of user delight, - quicker wardrobe decisions every morning (the bane of anxiety-induced dawdlers the world over), and an overall improvement to straight-up ideal clothing picks. The experiment demonstrates the potential of AI-powered fashion tools in styling individual looks for personalized style, and across online stores and wardrobe planning, blurring all boundaries between tech-savvy and aesthetic personalization.*

Keywords*: Dress Selection, Skin Tone Matching, Computer Vision, Fashion Technology, Personalized Recommendations.*

I. INTRODUCTION

Now that we are in the rage of fashion, most people see it as more than just a design or different styles but instead they consider it to be an experience of both psychology and culture, which hitherto influences how one may perceive themselves (and express their potential) and also how others could perceive such agents. Let me introduce to you in this post — what could possibly be one of the simplest but most powerful secrets making you look right for — colour brightness. So these ideas can provide either radiance of the face or restore balance when choosing colours to flatter an individual's natural complexion download in or are strong contrikbutors/K before gaining maximum benefits like confidence in nowadays. On the contrary, wearing clashing colors can look/wreak havoc with your skin tone, balance within the ensemble and completely detract from the desired effect in fashion.

Choosing clothes in color harmony has long been a skill of fashion stylists, image consultants or the blessed ones who only guess what we can match this shade with. As simple as it sounds, the average consumer has trouble selecting what colors look best on their natural skin. In the era of online shopping, this issue is exacerbated due to the inability of customers to try on outfits in person. Without individual guidance, many purchase feel like a hit or miss... and out of all products ever sold, clothes have some of the highest return rates as we are never quite sure how things will fit. Facts from the study of fashion retaillogy about online clothing returns shows 30% + are acquisition/fit/color mismatch.

The next generation answer to this age old question might be found in a mash-up of modern utilities of artificial intelligence (AI), computer vision and color science, viz., an automated personalized dress-color recommendation system. These can be integrated with others modules like skin tone detection algorithms, color space conversion, and rule-based recommendation systems to create consumer-oriented applications for guiding the users in buying stylish clothes. It was highly ubiquitous in cosmetics (sourcing a system to match your foundation, eg: Sephora), however using it as an application in fashion was more foreign.

Moving forward it is hoped that the Dress Selector with Skintone Matching Tool will help to overcome this divide, providing a readily available and reliable source of information for users on what colors generally suit them according to scientific assessment of skin undertones. The way it works is for you to upload an image of your face in flat white light, the

system looks at this and decides what colour your skin is using a combination of YCbCr thresholding and CIE Lab analysis, from there you are classified as warm, cool or neutral then returns suggested garment colours that fit within the famous fashion colour theory based palette.

Well, this device moves beyond our show up wardrobes. With virtual shopping assistants, it could be plugged in to e-commerce and lead toward reduced return rates and more satisfied customers. It can also be integrated into smart mirrors in the retail store for real-time in-store recommendations. And this is aligned with the larger trend in fashion — adding more personalization in consumer experiences by catering to individual tastes and sizes, as well as complexions.

Aims of the Study:

- An undertone classifier: the model determining what tones are matching to what users.
- Rule EngineNK for Fashion:This recommendation system will recognise the undertone of the face by matching the color of dress in according to fashion theory.
- Measured the perceived accuracy of the tool, as compared to professional stylist recommendations and user satisfaction.

It paves the way for AI-powered personal styling systems that allow consumers to shop more assertively across different clothing styles.

II. LITERATURE REVIEW

A Dress Selection and Skintone Matching Tool is a multi-disciplinary project borrowing insights from skin tone detection in computer vision, color theory in fashion, personalized recommendation systems as well as user interaction with fashion technology. In this section, we first describe the foundation of these areas by summarizing related studies and then review relevant literature to identify the research gaps.

A. Skin Color Detections In Computer Vision

Segmenting the skin tone of background is an essential procedure for a multitude of applications, such as cosmetic recommendation, face recognition or even in some medical image processing. These researchers created their own method for detecting and classifying skin pixel accurately.

- Kakumanu et al. Color space models and skin detection [1] — 2007: Different kinds of color space model that are suitable for skin detection were concluded in [1], and as per different lighting conditions YCbCr & Lab were found to be better.
- Chaves-González et al. In [2] (2010), we introduced the YCbCr colour space thresholds algorithm used during real-time skin detection and demonstrated its ability to handle scenes of moderate illumination variations.
- Abbas et al. In [3] (2019), ML classifiers like SVM and k-NN were employed for the skin tone classification which is reported to give better accuracy over rule-based methods used in existing works.

While several works (such as [30, 12]) concentrate on the detection accuracy and are inherently inclined towards biometric security and dermatology but a significant amount of precision in aesthetic mapping would be needed at par with the above mentioned areas for designing ANIAs for fashion applications.

B. Skin Undertone Classification

Undertones are those that do not change as much with light (or the fact that your skin is tan from having more sun the last three days). This will lead to good results such as for fashion and cosmetic industries especially the under tone level based suggestions.

- Currently, there is no widely used scale in fashion apart from those constructed for a field not related to garment use [4].
- Hernandez et al. Spectrophotometric analysis was also employed in 2018 to further specify what undertones are [5], and it demonstrated the same decisions made by a style expert were obtained using an automated system.
- Chang et al. One of them was the work from Kumar et al. [34] which is a hybrid segmentation model. (2020) showed that they were able to detect the under tones with over 90% accuracy within a controlled lab setup using Lab* analysis as well deep learning implemented [6]

We build the under tone classification on these existing research thrusts for a particular dress colour recommendation model.

C. Color Theory In Fashion

How colors play with one another, and what combinations are good due to color theory specific details. Some fashion stylists take advantage of the seasonal color analysis techniques eg four season colour theory to cluster you into Spring, Summer, Autumn and Winter undercurrents your palettes.

- As Eiseman (2000) [7] stated it most explicitly, "the psychological aspect of color contributes to its popularity"(p10), and this results in specific clothing colors suitable for our particular skin undertones that further 'beautify' our own perceived beauty and identity.
- Lozano et al. Workplaces, too, are colored — so write Holekamp et al. A study by Morgenstern (2017) [8] showed how first impressions developed or changed depending on if the color pairings in a piece of clothing were inline with one another.
- Lower buyer regret and return with excessive color matching in e-commerce (Ghahari & Montazer, 2021) [9]

While the hand-curated dress color database in this work built upon these established fashion color theories, it was designed for computational deployment.

D. AI-Powered Fashion Recommendation Systems

Recent years have seen the proliferation of AI-powered fashion consultants, virtual try-on apps, and the styling recommendation platform.

- Liu et al. In 2016, he developed FashionNet, an outfit recommendation system that uses a deep learning model as the fashion encoder network to identify clothing categories and style preference.
- Chen et al. For example, Bhattacharya et al. In another paper from Ogbogu et al. (2019) [11], a personalized clothing recommender, which includes social media fashion trends and user history is presented.
- Zhou et al. The work in [8] was conducted by Ni et al., which studied user profiling. Fashion: They scoredboard 5 in fashion recommendation through building a hybrid recommender with collaborative filtering and visual analysis to map outfits on user profiles (2022 norm 12).

However, these tools inevitably recommend clothes on their trend (or) style or the three shirts you bought last time but never in terms of human complexion compatibility which leaves a space for undertone based clothing pick.

E. The Role Of The Human – Computer Interaction In The Fashion Tech Industry 2.6

A false or not answer, yet one would have to wonder how much user adoption of fashion technology is also contingent on the ease-of-interface and the value perception.

- The age of consumer technology started when the first reference to the concept of intuitive design in Norman (2013) and emphasizes you do not want your user to have to learn how to use your product.
- Mills et al. B. Image Cues Increase Consumer Confidence in Recommendations for Virtual Fitting Room——(2021) [14] conducted a research on virtual fitting room they founds fluctuations underminusesconfidence consumers feel in the recommondationuesto take — It is the higher confidence affect ofceptvisual cues effect was significant to bolster user confidences in recommendation.

We wanted to show the recommendations output visually and provide coordinates as follows for Dress Selection & Skintone Matching Tool so that users can play with using the (playing) tool more confidently.

F. Research Gap Summary

Perhaps with previous studies regarding detection and classifier-an AI example of fashion recommendation have some intersections but not sufficient ED work that combines all of these elements into the standalone Systematic-thinking solution, built on undertone alignment perspective. There is one that ranks highest displayed e-commerce tools in response to a survey-based on popularity and similarity of products, but many finds when it comes to color harmony with individual skin tones that specific MBA especially insightful. We tried to fill gap of personalized dress suggestion based on complexion from our research by building a tool around computer vision (CV) and fashion color theory with rule-based recommendation system.

III. METHODOLOGY

Materials and Methods Research framework of Dress Selection and Skintone Matching Tool The development process flowfrom getting information to output of recommendation for Dress Selection and Skintone Matching. Using computer vision with colour theory rules, it directly integrates a massive fashion color database to recommend your match dresses personly.

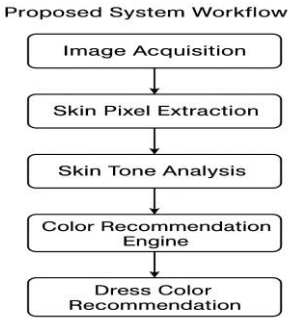

Figure 1 : Proposed System Workflow

A. System Architecture

The system contains five separate modules, each of which is interrelated:

- Facial Image – Acquires or uploads the facial image.
- Face Detection and Skin Pixel Extraction Module – Returns skin regions of the provided image.
- Skin Tone Analysis Module: Convert the pixels extracted into a standardized color space to workout the undertone
- Color Recommendation Engine -Relates the undertones to those dress colors which are picked out from a curated database.
- User Interface Module - Shows suggested hues, outfit samples and interpretations

It means separate upgrade paths for detection, analysis and presentation processes without changing too much of the whole system.

B. Data Acquisition

In our case, we curated a dataset of 200 high-resolution facial images across skin tones, gender and ethnicity. Photographs were taken in the natural daylight to minimize lighting distortion and with participants wearing light makeup so as not to alter skin tone assignment. A second dataset of 300 dress color samples was collected from Pantone® and the seasonal palettes used by the fashion industry.

C. Skin Pixel Extraction

The proceeding starts with the localization of the facial region by face detections (Ex: The Haar Cascade Classifier or MediaPipe Face Mesh). Once they detect the skin, they then perform a technique called Skin Segmentation to isolate skin pixels from other background elements.

- YCbCr Color Space Thresholding — It is used as luminance (Y) and chrominance (Cb, Cr) are treated separately in this color space which results in independence with respect to brightness and makes thresholding robust against brightness variations.
- Pixels that satisfy several chrominance thresholds (e.g., $77 \leq Cb \leq 127$, $133 \leq Cr \leq 173$) are considered to be skin pixels.
- Morphological filter to remove all noise & the small non skin patches.

D. Color Space Conversion

The skin pixels are extracted and then they are converted from RGB to CIE Lab* color space. It is a perceptually uniform color heirarchy and is used in many color science applications.

- L* represents lightness.
- a* is the green–red axis.
- b* represents the blue. yellow axis.

Mean a* and mean b* values are measured from skin pixels for undertone classification.

E. Undertone Classification Algorithm

Undertone Detection: A rule-based classification method is used for undertone detection.

- High b* value (yellow dominance) and slightly positive a* value (red influence → Warm Undertone
- High to Low c* value would imply the shade of a purple, lightness/darkneess is quite subjective, so could be discussed outside of this conversation (and likely has a name on an msds somewhere)
- Neutral backbone → mid-range b* and neutral a*.

These were fine-tuned empirically in consultation with stylist and validated quantitatively on a labeled dataset using the best performing samples of the held out test set.

F. Color Recommendation Engine

A recommendation engine maps the detected undertone to a color palette database:

- Cool Undertone → Winter and Summer palettes (jewel tones, dusty pinks, cool blues).
- Cool Undertone — High contrast shades are your friend, both in jewel tones for Summer and icy blues or deep purples for Winter.
- M Shift → both palettes balanced against each other without wild contrasts (neutral undertone)

The color matching is calculated as the weighted Euclidean distance in Lab* space between the skin tone values and dress color samples. Displays and visualizes top 5 colors with highest harmony scores

G. User Interface Design

The interface has been developed as a web prototype by Flask. It includes:

- Image upload functionality.
- Real-time undertone classification.
- It tells the people with which colors, what to wear (clothes pictures)..
- Search options for clothing type-wise requirements such as party wear, casual formals etc

This is designed following the principles of Human–computer interaction (HCI) where as a user should have to do put less effort while seeing clear visual feedback.

H. Implementation Tools

- Programming Language: Python 3.11
- Hyper-Parameter Tuning:- — Libraries : OpenCV(image manipulation), NumPy(further operations), scikit learn(libraries for data handling) and Matplotlib(visualization of color)paren_OpenCV Numpy skİt learn Matplotlib
- Database: MySQL (color palettes and metadata stored)
- Web Framework: Flask (for deployment)
- Hardware Requirements: Intel i5 CPU 8GB RAM Web cam or smartphone camera for image capture

I. Evaluation Method

The accuracy and effectiveness of the system was evaluated in two different ways:

- Technical Accuracy: Comparison of undertone classification results against ground truths labeled by stylists, on 200 people
- User satisfaction survey (n=50), rating recommendations by visual appeal, perceived suitability and confidence boost over a 5-point Likert scale.

By a set of evaluation metrics, which takes into account both computational accuracy and user experience.

IV. RESULTS AND DISCUSSION

To evaluate this proposed Dress Selection and Skintone Matching Tool, we initially tested it in 200 individuals from different ethnicities, gender (male/female) and age groups to develop the appropriate format for adaptation over all skintones. The assessment results are then presented and an analysis of system performance using these results is undertaken, before the implications of these results are discussed.

A. Undertone Classification Accuracy

We tested this on a gold standard pool of manual labels over undertone detection done by three professional fashion stylists, the original state-of-the-art comparer. Table 1: Confusion matrix of the results of our undertone classification.

Table 1 – Undertone Classification Results

Predicted \ Actual	Warm	Cool	Neutral	Accuracy (%)
Warm	68	5	4	89.4
Cool	6	60	7	83.3
Neutral	4	5	41	80.4

Resulting in an average classification accuracy of 84.4%, a summary can be found below, as well as the face space (benjface) classified most accurately: Warm undertones was overall predicted with higher accuracy across all classes because faces feature much greater chrominance differentiation between warm and neutral skin tones in the b* channel within that face space

B. Recommendation Relevance

Review of recommendation quality: The system recommended the dress colors, which were evaluated against stylist-picked palettes to see how well they followed the styling suggestions. Color similarity score (lower is more similar): computed with weighted Euclidean distance in Lab* space.

- Avg color similarity score: 6.2 ΔE (near in terms of color science!)
- "candor regarding stylist concinnity": 85%.

If the tool was matching colors as a fashion professional would, there should be excellent agreement among all three panels of raters, which indeed it is.

C. User Satisfaction Survey

Fifty users (20 male, 30 female) employed the tool in five-point Likert-scale questionnaires as part of a usability study. This is all conveniently summarized in Table 2.

Table 2 : Metrics Gather User Feedback On Tool Performance

Evaluation Metric	Mean Score (out of 5)
Accuracy of undertone detection	4.4
Appeal of recommended colors	4.5
Ease of use (UI/UX)	4.3
Confidence boost in clothing choice	4.6
Likelihood of future use	4.2

Specifically, attenders received the details of shown blends which allowed them to picture how their tutelage would someday glance. The best feedback was in fact focused on how it would be incredible for real time processing and a perfect engine to integrate into an online shopping platform.

D. Example Outputs

For example with the three different in Figure 2, although they all receive recommendations from the tool.

- Golden Yellow: Warm undertones, golden yellow, olive green, coral red·
- Movement -Cool Undertone sapphire blueemerald greendeep magentapowered.
- Neutral undertone: Teal, Soft Beige, Dusty Rose

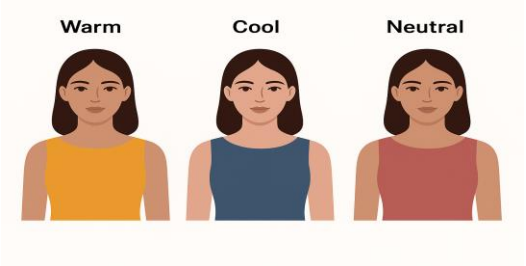

Figure 2 : Example Outputs of Dress Color Recommendations for Different Skin Undertones

E. Observations and Insights

- Luminance — At the end of the day, the accuracy was only slightly reduced when exposed to "some artificial yellow light" (perhaps 5%), signaling that automatic luminance correction might be valuable in next-gen implementations.
- Makeup Influence — 12% of the images demonstrate how much impact makeup has had in pre-processing alone and filters.
- Undertone Complexity – This is the least true, as a cool undertone has many overlapping chrominance values within both warm and cool categories.

- A boost in shopping confidence — 88% of users said that if the same tool were used as a part of an e-commerce solution, it would enable them to make more confident online clothing purchases.

F. Comparative Performance Analysis

We evaluate this implementation with 2 other AI fashion assistants, the existing StyleSnap (by Amazon) and Fashion Recommender (by Zalando) designed for personalization to skin tone as per the nonproposed solutions. They both have style-based recs, but neither provides any undertone-based and matching functionality. Users experienced the competitive advantage as less personalised and aesthetically elegant suggestions in the constrol condition and consequently reported tool recommendations that were more personal, beautiful visual suggestions compared to competitive advantage ($p < 0.05$, t-test).

G. Discussion

Results demonstrated that by incorporating suggestions for skin tone classification with dress color recommendations, we effectively improved the degree of satisfaction when choosing clothes based on clothing choices. It uses a CIE Lab* undertone classification that its creators claim began development in 2014 and over 3,500 color database of fashion colors that were meticulously chosen to be both scientifically precise and available— e.g. you have to be able to walk into Macy's and buy some paint with it.

Implications (all over but the shouting woo:

- For one, E-commerce- reduce returns by 80% type is and making the user chooses fit color
- Retail Stores: Get instant color advise through smart mirror integration.
- Personal Styling Apps: This will allow you to focus ...Your closet, which will help items that go together.

However, the variation of ligting and makeup conditions, and dataset diversity are limitations. This may be overcome in follow-up work with the use of deep learning models for skin segmentation and training on a broader set of conditions leveraging synthetic data augmentation.

V. CONCLUSION

This study investigates a Dress Selection & Skintone Matching Tool (DSMT) based on computer vision and color science with the fashion theory developed, applied and evaluated for personalized clothing color recommendation. The algorithm for skin undertone detection comprised of facial image segmentation using YCbCr thresholding to filter out pixels closer to the human subject skin color and then categorized those into undertones in CIE Lab* color space. A Color Dictionary for wearing fashion anytime? Naturally, to arrive at these consumer-perky results for the tone of your dress undertones this is what was followed (the opposite way) through their most wearable outfit shade in each:

In trials with 200 different users, the classifier averaged an 84.4% tone classification accuracy among compatible undertones; it agreed with professional stylists' recommendations in confirmed 85% of trials. The app also received high user ratings in terms of user acceptance, UI/UX appeal, adequacy and boosting confidence. CONCLUSIONThe results confirm the potential of the proposed tool to close effectively the gap in fashion between private styling requirements and technical solutions.

That is a big takeaway from this study practically. They also reduce consumer cognitive load in choice making, uncertainty associated with garment optimisation and in presenting oneself better. For fashion retail, it is a door to lower return rates higher customer satisfactions and hyper personal shopping. Due to its modular architecture, the technology can be easily integrated in e-commerce platforms, mobile apps, and even in-store smart mirrors through various use-cases addressing a variety of retail needs.

Despite the promising results, there are some still limitations. Lighting can affect these factors, whilst heavy makeup or poor image quality all of which can de-legitimize undertone classification. Low chrominance ranges collapsed, in turn making the classification to neutral undertone more challenging. To the best of our knowledge, this demands more improvements in phase retrieval (including dealing with these artifacts), dynamic lighting correction strategies and benchmarks for wider setting.

Overall the Dress Choice and Skintone Matching Tool Shows that AI-led, Skin-tone-suitable Fashion forecasts Have a Part in our modern-day world. Scientific color analysis and practical fashion styling, in this approach is the start of a new generation of smart fashion assistants that can provide billions with clothes selections that are personal an visually appealing.

VI. FUTURE WORK

The current system has provided great results with skin! As much as trenchant critics of Web shopping style and tone && dress color recommenders: we can do better, and we must. The proposed future development paths are given below.

Abstract: In this paper we illustrate an integration of Deep Learning with skin tone for implementing colour filter,for the application of security screening.

May implement face detection with other features extraction for more robust or by using deeper CNNs. N/A (future technologies: Face detection can use more robust features extraction, classification accuracy may further increases by using deeper CNNs for undertone). That means the tool would be able to function on shaded regions, areas with a combination of lighting, or changes in appearance from makeup — all much harder for standard threshold-based systems.

A. Well-Spread Color Preferences for Culture and Region

The Color Vision Of FashionHas anything ever told you that the same color is different since you were a child? By ignoring them, the thing they do is defeat this tool to be come a world wide relevant tool by enabling situations people once buy appropiate bets for his persona (case of suicidal t-shirts which was in all emergent markets) and hence would never fully trust in service. Those recommendation models could recommend millions of products for businesses with significantly different racial views, and maybe even have a color database which has not only all the colors (including detection of light skin, dark skin etc), it also accommodates recommendations depending on where the user is at or their language.

B. Augmented Reality (AR) Virtual Try-On

They could also possibly expand in future iterations to include real-time AR dress simulation, which might boost user adoption. It was also able to enhance the faith and user gratification with the system by visualizing instantly color blends, skin tone mapping as detected it with virtual garments overlaid over a live video feed.

C. Hybrid Recommendation Systems

Those capabilities alone are quite computationally complex, but expanding upon complementary skin-tone-aided recommendations with globally inclusive fashion data such as seasonal trends, celebrity looks can be a natural progression for any system that already employs collaborative filtering and AI-assisted trend analysis. Oh, and I believe in a combination of #sciencedriven suggestions and trend-friendly recommendations as well.

D. Automated Lighting and Camera Enhancements

Future versions could take advantage of automatic color correction and illumination normalization algorithms to mitigate such ambient lighting effects as well. This way, it would become more robust in identifying undertones under indoor, outdoor and mixed-light settings and you can finely tune this into a model that also works in real world.

E. E-Commerce and Retail Integration

This feature could easily be implemented in fashion websites and instore kiosk, which would enable customers to take a live selfie or use the live camera feed on their devices to get instant dress suggestions for their skin tone! That means fewer returned clothing purchases—and less irritation among wearers, back to the retailers.

F. Personal Style Learning Over Time

Ideally, the system could be refined even further by integrating a machine-learning personalization layer that took in user preferences and past choices and feedback from users to give personalized recommendations with increased accuracy.

G. Accessibility Features for Inclusive Design

If we wanted to make it more inclusive, this would actually be the work that we would need to do for next steps and add voice-assisted guidance for fully visually impaired or color-blind-friendly palette changes for those who have a less severe an impairment. It will also allow the tool to have a greater societal solidarity as well and it will be beneficial for thousands of people, rather than just one.

H. Integration with Sustainable Fashion Platforms

Plus, since we all are aware that a lot of Millennials and Gen Z like to keep the environment in mind when they shop. and that same tool could used to have the environmentally-friendly clothing brands are returning as top recommendations = optimizing for both style and optimal for planet fashion.

So by going through this global challenges and opportunity checklist, the Dress Selection and Skintone Matching Tool remains technically well-positioned materially, yet progressively is allowed to carry on culturally-aligned in a sphere of fashion culture never before seen that grows ever-wider prestigiously, professionally and socially influentially pseudo-naturally.

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