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A Complexion based Outfit color recommender using Neural Networks

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Abstract: **— Shopping apparels and outfits either online or in stores is always a big task as it requires people to choose the most suitable outfits that resemble the latest fashion trends, have the perfect blend of outfit color combinations which matches their skin tone and looks as well. Thus confused customers need an advisor who can guide them through this outfits selection process. The aim of this paper is to propose a system which serves as a personalized fashion advisor. To serve this purpose, "Pocket Fashionista" which is a personalized Fashion Advisor is introduced that provides the best outfit and color combination recommendations to the users based on their complexion which will make them look great and feel confident about their appearance. The users can also visualize these recommended outfits on their own body to understand how the outfits and color combinations look on them thus enhancing their user experience. Weather based seasonal recommendations are also provided to the user. Hence, the system will help the E-commerce shopping websites, merchants and sales executives to master the real time demand of customers.**

Keywords — personalized recommendations; virtual trials; similar outfit recommendations; weather oriented recommendations; Indian skin tones classification, fashion advisor, real time demand satisfaction

I. INTRODUCTION

Color and fashion play a very important role in one's life. And in fact, the perception of fashion differs in men and women as women are most likely to differentiate within different shades of colors than men. The conventional fashion practices usually draw out conventional outcomes in peoples' lives. On the other hand research shows that coping up with the trend helps to be socially active and confident. Most of the time people compromise with the outfits, their colors and fail to match them with a suitable pair of that outfit and accessories due to weak color sensibility and fashion sense and usually need someone to suggest colors and outfits for various events, vacations and much more.

There are a few misconceptions which implicate that to cope up with the trend or to look fashionable, people have to spend more money. Or being presentable and getting well fitted and good outfits are only limited to parties, dinners, etc. But on the contrary, being presentable does not mean buying expensive clothes but small changes in matching colors of the outfits or getting outfits which go well on the skin complexion and body type can bring a great change. Hence "Pocket Fashionista" aims to be a personalized Fashion Advisor of every person who wants to look trendy and fashionable.

II. LITERATURE REVIEW

With this context, many systems have been developed to provide personalized recommendations to the user. In [1], a recommendation system for clothes based on Season, occasion, posture and skin color is proposed. Here recommendations are based on personalized clothing styles according to fabric styles and colors. A broad classification of the personalized indicators for recommendation makes this work remarkable. Also a simple mobile interface which is provided to the user gives an optimal solution. User preference is also given importance in certain works such as giving recommendations from the user's closet or wish list.

Another few approaches go with the user's input that is taken into consideration for providing recommendations. Knowledge graph technique is used for such implementations wherein it constructs knowledge graphs of the user, clothing and context. The Apriori algorithm is used here to capture the intrinsic correlations between clothing attributes and also the context attributes[4]. It makes the recommendations that are most similar to the user's clothes by calculating the similarity of clothing ontology. This also improved the accuracy and efficiency of the recommendations made. Also, some research works made recommendations that were particularly suitable to a particular user as per his/her personal preferences and his/her history of purchasing clothes. It is also based on his/her previous evaluation of the system[5].

An improved approach which gives a really personalized recommendation system is where users are prompted to provide their photos so as to give recommendations that suit them well based on their facial features and skin tone. Skin segmentation technique has powered this system[8]. Providing weather based suggestions for apparels is a challenging task to be achieved. The user is given personalized recommendations based on the ongoing weather so that he can feel both comfortable and trendy in whatsoever weather going on[6]. Virtual trials of clothes have gained importance over the years. This not only helps to visualize how the clothes will look on the user's body but also helps to save the user's time in trying out the clothes[2][7]. Basically image warping techniques are used for solving this problem. Fitting the clothes to 2D or 3D models is achieved by Warping techniques. Complexity of the model's pose and the scenario when body parts can overlay over the clothes has been well managed in such solutions[2]. Event based recommendations are given to the user so that he can get proper fashion tips which he can follow and impress his social circle[3]. This makes him confident to attend the social events by following the latest fashion trends via a personal fashion advisor.

III. Pocket Fashionista

"Pocket Fashionista" is an outfit recommendation system with various modules like - Skin Tone Detection and Classification module and outfit color recommendations, Similar Outfit recommendations, Weather based outfit recommendations and Virtual trial Room. The overall block diagram of "Pocket Fashionista" can be visualized in Fig. 1 shown below –

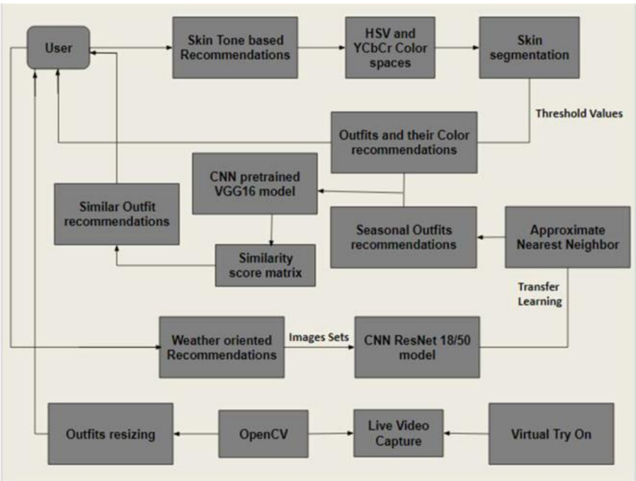

Fig. 1. Pocket Fashionista Flow diagram

A. Skin tone based Outfit Color Recommendations

The user is prompted to upload his/her picture. The system then classifies the person's skin tone from the Indian skin tones meter using OpenCV over a range of around 5 different tones namely - Fair, Wheatish, Medium Brown, Brown and Dark. Fig. 2 describes the overall workflow of this module.

The three color spaces for segmenting skin from the user's image are RGB (Red, Green, Blue), HSV (Hue, Saturation, Value) and YCbCr (Luminance, Chrominance) color models. Then skin segmentation from the user's image takes place. The BGR components are extracted from the image.

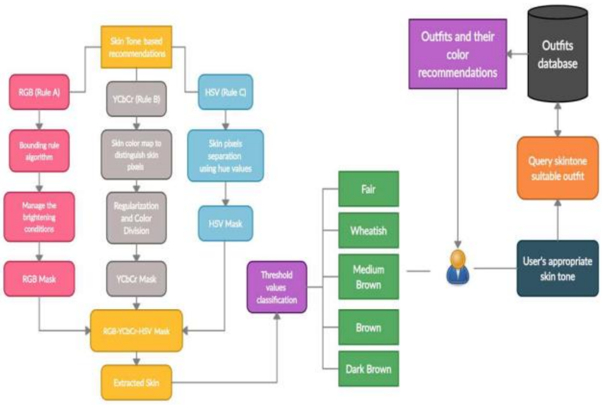

Fig. 2. Skin tone based outfit recommendations

1) RGB color space :
RGB values fall in a range of 0 to 255. For eg., RGB(0, 0, 255) is given as blue color, as the last parameter ie. Blue is set to the highest possible value 255 and the other two parameters are set to the lowest value 0.

2) HSV color space :
The position of the particular color in color space is set by Hue from 0 to 360 degrees. Value is a percentage value for luminosity and also Saturation is a percentage value both considered from 0% to 100%.

3) YCbCR color space :
The YCbCr transformation from RGB (red, green, and blue) image source is as given below :
$Y = 0.299 \times R + 0.587 \times G + 0.114 \times B$
$Cb = -0.1687 \times R - 0.3313 \times G + 0.5 \times B + 128$
$Cr = 0.5 \times R - 0.4187 \times G - 0.0813 \times B + 128$

The Y component shows the picture in the same way as it is, only in black & white (low brightness & high brightness) mode. To calculate the Y component, the source image is converted to grayscale. Cb and Cr images contain the Blue and Red components of the source image respectively.

4) Skin Thresholding Algorithm :
In this algorithm, the skin part is separated from the non-skin area using a linear separation method. This technique proposes fixed skin limits in a particular given color shading space.

A. RGB (Rule A) - For this, initially the RGB bounding rule algorithm is implemented where the light illumination effects under which the user has taken the picture is also managed. In this way, the skin part is classified by heuristic standards in which two unique conditions are taken into consideration like uniform light conditions and flash light or lateral enlightenment.

Uniform daylight illumination : (Rule1)
$R > 95, G > 40, B > 20,$
$(\mathrm{Max}\ \{R, G, B\} - \min\ \{R, G, B\}) > 15,$

$|R - G| > 15$, $R > G$, $R > B$
Flashlight or daylight lateral illumination : (Rule2)
$R > 220$, $G > 210$, $B > 170$,
$|R - G| <= 15$, $B < R$, $B < G$.
Both the rules have been combined by ORing them. So the final rule that is generated is as follows :
RGB_Rule = (Rule_1) ∪ (Rule_2)
which outputs a RGB mask.

YCbCr (Rule B) - A skin color map has been utilized on the chrominance segments of the source image to distinguish the skin pixels. Many procedures of regularization are used during the calculation at that point of time to separate the areas of skin color pixels bound to have a place with the facial locales. The color division step is used here. It was found that spaces of Cb and Cr color ranges tend to delegate for the skin color reference map in the YCbCr color space as given below :
$Cr <= 1.5862 \times Cb + 20$
$Cr >= 0.3448 \times Cb + 76.2069$
$Cr >= -4.5652 \times Cb + 234.5652$
$Cr <= -1.15 \times Cb + 301.75$
$Cr <= -2.2857 \times Cb + 432.85$

After applying this mask, the YCbCr mask picture of the original image is produced. Fig. 3 shows the Bounding rule of Cb-Cr color space and their components can be seen in Fig. 4.

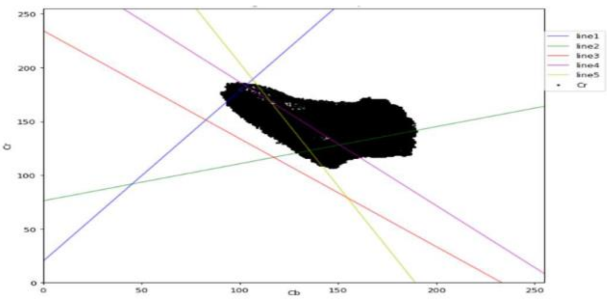

Fig. 3. Bounding rule for Cb-Cr Space

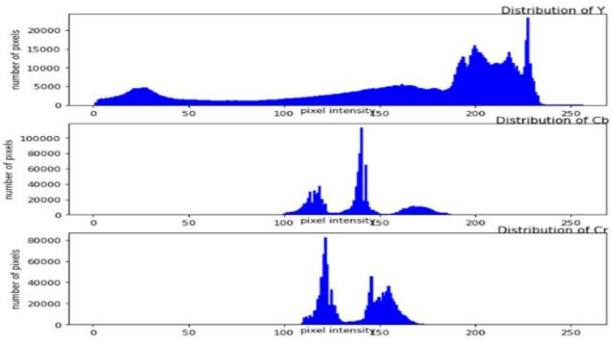

Fig. 4. Y-Cr-Cb components

HSV (Rule C) - The Hue values perform the separation of the skin and non-skin areas in the HSV color space. Fig. 5 shows the HSV skin color distribution of H versus V & S resp. Based on the experiments, for generating the Hue mask of the input image, the hue value can be estimated as:
$H < 50$
$H > 150$

RGB-YCbCr-HSV - Now all the RGB, HSV and YCbCr masks are combined to generate an algorithm which generates the RGB-YCbCr-HSV mask, which when applied on an input image generates the extracted skin from it.

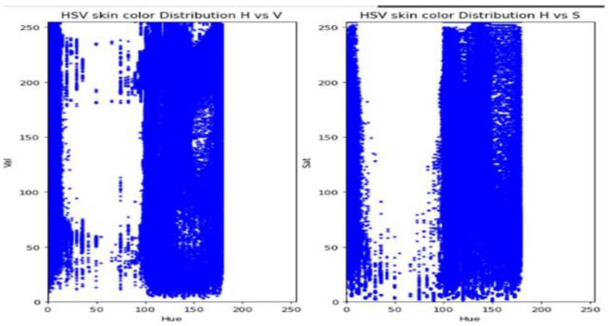

Fig. 5. HSV Skin color distribution

Hence in order to get a good output accuracy, the coefficients of some of the above mentioned equations are required to be changed slightly. Now the extracted skin is classified into 5 different Indian skin tones namely - Fair, Wheatish, Medium Brown, Brown and Dark. This classification is based on the threshold values of the skin extracted from the image which gives good accuracy.

The ranges for a skin pixel used in this proposed algorithm are as follows:
$0 <= H <= 17$ and
$15 <= S <= 170$ and
$0 <= V <= 255$
and
$0 <= Y <= 255$ and
$135 <= Cr <= 180$ and
$85 <= Cb <= 135$

To find the dominant colors, the K-Means Clustering Algorithm has been used. K is used to cluster the pixel data based on their threshold values. Further the user's skin tone is classified by particular threshold values into Fair, Wheatish, Medium Brown, Brown and Dark.

5) Complexion based recommendations :
Skin tone classification model explained above passes the user's appropriate skin-tone to this module. Based on that the specific outfit colors to particular skin tones have been defined. The “men-formal-shirts.csv” dataset has been used for recommending the suitable colors to the user. In the dataset attributes like “Description & Color” have been considered to extract the color name of the clothes. Accordingly outfits are shown to the user by fetching images of the clothes of the recommended colors from the

dataset and using the matplotlib library, the images are plotted for recommendations.

B. Weather oriented Outfit Recommendations

Seasonal recommendations have been built on Convolutional Neural Networks with transfer learning from ResNet and Approximate nearest neighbors. The idea of the overall working of this module can be understood via Fig. 6.

1) Conversion of images to embeddings :

The DeepFashion dataset has been used for weather oriented recommendations. Due to the huge size of the dataset, only version 1(v1) of the data with 24K+ images has been worked upon. Around 46 categories of outfits are there in this dataset. The seasons considered are - Winter, Summer, Spring and Autumn. Images are converted to categorical embeddings.

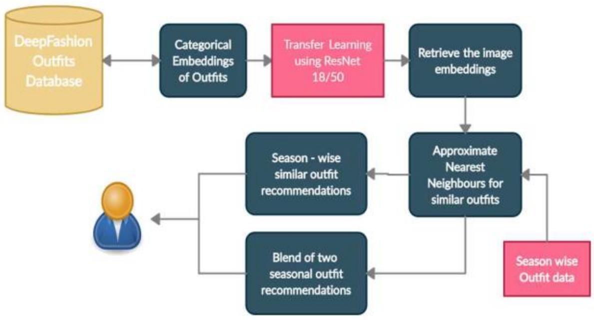

Fig. 6. Weather oriented Outfit Recommendations

2) Conduction of Transfer Learning from ResNet :

Resnet 18/50 layers have been used for training the CNN model. There are many layers for Resnet, like resnet18, resnet34, resnet50, resnet101, resnet152; where the numbers are the number of layers. The more the layers the model is more accurate but takes longer to train. The top 1 and top 5 accuracies were aimed upon. Resnet18 is a simple model that can be trained on a free tier. The model was then evaluated for the classification of the categories of the clothes wherein the predicted and actual outputs were observed to be the same giving a 100% accuracy score with 0% loss.

3) Use of Fastai hooks to retrieve image embeddings :

Now the image embeddings were retrieved and the saved model is loaded for further process. It takes time to populate the embeddings for each image. The 2nd last layer of the model is found to store the embedding for the image representations. The last linear layer is the output layer. The data is prepared for generating recommendations excluding the test data. The trained model gives the embeddings.

4) Use of Approximate Nearest Neighbors and embeddings centroid detection to obtain most similar images based on the embeddings :

Finally, the Approximate Nearest Neighbors algorithm is used for generating the similar clothing recommendations. Images similar to the centroid are also computed. A set of season-wise images are also passed to the model for generating similar recommendations. 24 outfits are selected for each season. They act as the seed images for Seasonal Collections. Only images are passed into the model; the model does not ingest additional attributes/descriptions/product details; this is because the model is required to automatically learn and detect the style of fashion images passed into it without further human/machine labeling. Centroid embeddings then merge all the seed images into one representation by averaging the values across all dimensions. Finally, Approximate nearest neighbors is applied to return outfits closest to the representation. Thus the group of similar images as per the season passed are recommended to the user.

C. Virtual Try On

The user can get a demo trial of the outfits on his/her own live video stream through a webcam/camera. This way the user will be able to try out the suggested outfit without even trying it on his/her body. Initially, the user's webcam is turned on to catch the live video stream. Then the user needs to adjust his posture within the frame of the outfit and then the algorithm works to adjust and resize the clothes on the user's body by object detection. Fig. 7 shows the typical block diagram of Virtual trial.

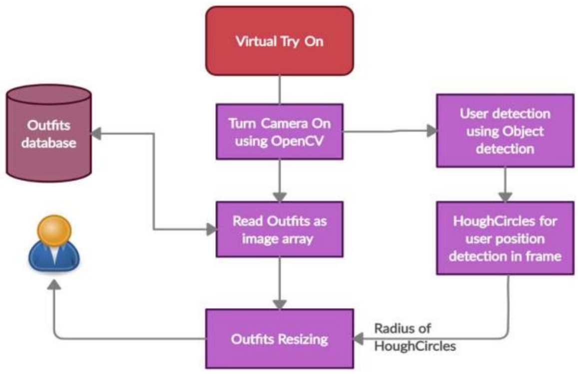

Fig. 7. Virtual Try On

The OpenCV library of Python has been used for capturing the live video stream. Then all clothes to be tried on are read. The images that the user can try on are resized to fit on the user’s body. The person in the video stream is detected using Object detection. Then the HoughCircles method is used for estimating the size of the clothes for further resizing. HoughCircles() have been used to determine the area in which the user is standing in front of the frame. According to the obtained measurements of the radius, the resize() function of the imutils library resizes the clothes. Resizing takes place by increase/decrease of either the height/width of the clothes. The user can move back or forward to check out different clothes. If the user wants to save a screenshot then he/she can also do so. The outfits are stored in a large dataset from where each outfit is read as per the user's current choice. The user has been given a functionality to navigate Next/Previous between the outfits and then try it on.

D. Similar Outfit Recommendations

This is a Content based recommendation system wherein Transfer learning is used. The Feidegger dataset – composed of dress images and related textual descriptions of 8732 high resolution images has been used here. The pretrained VGG16 model is used here to extract the relevant features from the dress images and build a similarity score on them. The VGG16 CNN model is cut at the second-last layer, so for every single image a vector of dimension 1x4096 is obtained. The model has been trained for 2000 outfits as in for experimentation purposes. The train test split is 80-20%. The training data is used for building a similarity score matrix. Fig. 8 gives a clear idea of how similar recommendations are made.

Then predictions are made on the data by using the CNN model. The similarity matrix for the other clothes in the dataset is then computed using the cosine similarity method to find the similarity score.

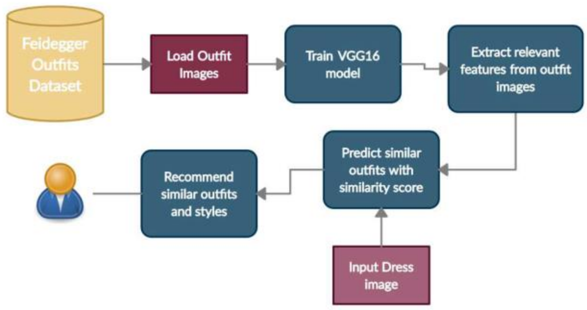

Fig. 8. Similar Outfits Recommendations working

Whenever a dress image is passed to the system, its similarity with all the dresses stored in 'train' is computed and then the most similar (with the highest similarity scores) dresses are selected. Finally the most similar outfits ranked by their similarity scores as per the user's input of clothes as per his choice are plotted.

IV. Results

For skin segmentation, there is a combination of RGBYCbCr- HSV color spaces. The results of skin tone detection are quite satisfying due to the novel approach proposed as seen in Fig. 9 and Fig. 10. The Fair and Brown complexion based recommendations can be seen in Fig. 11 and Fig. 12 respectively.

Fig. 9. Fair Skin tone

The outfits that are recommended particularly for the Winter and Spring season combined can be seen in Fig. 13. This model is observed to be giving an accuracy of 92.61% as the top accuracy score among all other epochs as seen in Fig. 14.

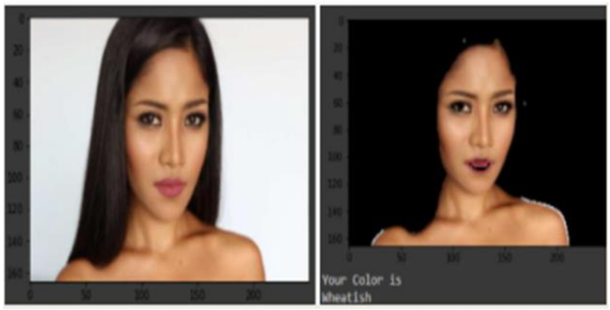

Fig. 10. Wheatish Skin tone

Fig. 11. Outfit color recommendations for Fair Skin tone

Fig. 12. Outfit color recommendations for Brown Skin tone

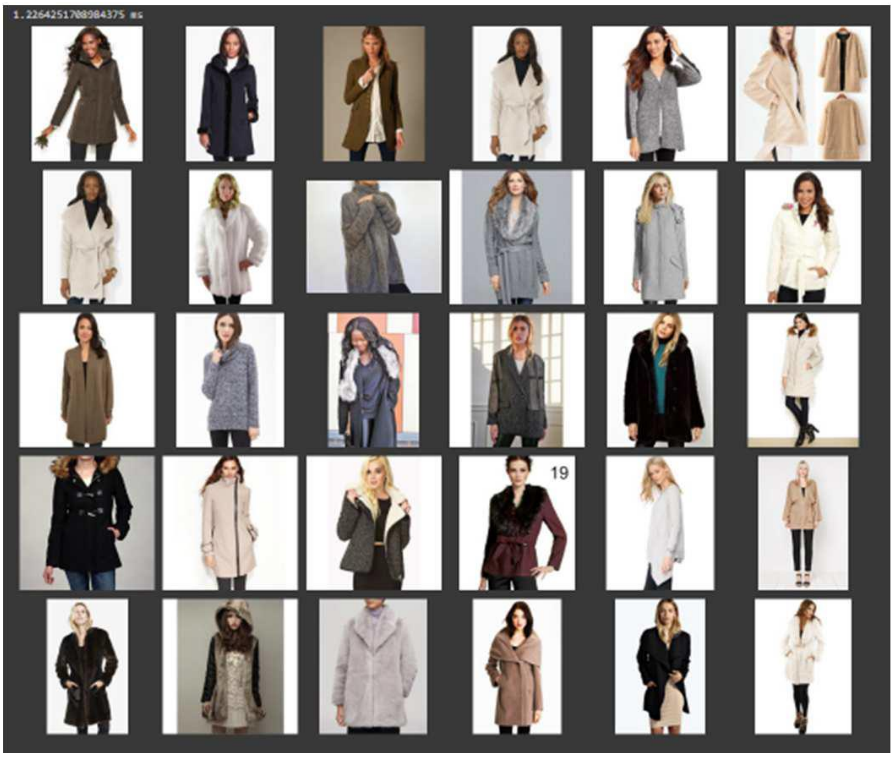

Fig. 13. Outfit recommendations for Winter and Spring

80.00% [8/10 2:14:06<33:31]

epoch	train_loss	valid_loss	accuracy	top_k_accuracy	top_k_accuracy	time
0	1.471898	1.353760	0.602250	0.602250	0.897625	16:54
1	1.451260	1.388633	0.593200	0.593200	0.891875	16:19
2	1.440240	1.380244	0.594750	0.594750	0.894000	16:32
3	1.409721	1.315045	0.610425	0.610425	0.905450	16:39
4	1.335867	1.257601	0.634525	0.634525	0.911550	16:36
5	1.315253	1.238566	0.639000	0.639000	0.915575	16:48
6	1.275752	1.166933	0.658325	0.658325	0.923950	17:06
7	1.228926	1.135368	0.664400	0.664400	0.926100	17:09

20.75% [339/1634 03:15<12:28 1.1987]
Buffered data was truncated after reaching the output size limit.

Fig. 14. ResNet 18 model accuracy

The virtual try on results can be seen in Fig. 15 and Fig.16. They are indeed giving a good fit on the user's body in real time thus enhancing the user experience. The user can also get similar outfits for a desired dress he/she wants as in Fig. 17. The dresses are seen ranked by their similarity scores.

Fig. 15. Virtual Trial - Outfit 1

Fig. 16. Virtual Trial - Outfit 2

Fig. 17. Similar Outfits Recommendations

V. FUTURE SCOPE

Along with the outfit color recommendations based on skin type and categorical color recommendations based on weather, the system may also recommend accessories based on the selected outfits like watches for men, earrings, shoes, bags or purses for women. This concept and technology can be adapted by established online platforms where they can integrate this system to improve their customer engagement with the website and also provide optimal solutions to the customers.

Introducing weather based recommendations regardless of any particular area, its geographical location and the climate conditions in those areas can keep up with fashion. The system will juxtapose the color recommendations along with the weather API which will suggest the climate type and accordingly provide feasible and suitable outfits. Further one more module that is event and occasion based recommendations can also be implemented. There are various events to dress for and the system can also recommend outfits based on events such as weddings, parties, etc. Users can also pre-plan their outfits according to the upcoming event, as per the calendar application.

VI. CONCLUSION

Thus the perplexity of choosing various suitable colors of outfits is minimized by the featured modules. The proposed system recommends outfits and their color combinations to the users based on the skin tone of the user. By isolating the pixels of skin color, the predicted output is processed for further recommendations which gives a feel of personalization. Categorically, the outfits are placed which gives a personal touch to the recommendations and users will be able to find suitable combinations just by uploading their picture. A virtual trial room is also provided for the user to try on the recommended outfits. This feature allows the user to figure out the outfit suitability, its match with the skin complexion and the user will be able to experience the dynamic output presented by this module. Along with the recommended outfits, users can also try different clothes of similar types which will be recommended by the system. The system will thus help to minimize the time required for choosing an outfit and thus will result in efficient shopping and outfit selection process.

REFERENCES

[1] L. Hao and M. Hao, "Design of Intelligent Clothing Selection System Based on Neural Network," 2019 IEEE 3rd Information Technology, Networking, Electronic and Automation Control Conference (ITNEC), Chengdu, China, 2019, pp. 1789-1792, doi: 10.1109/ITNEC.2019.8729417.

[2] K. Ayush, S. Jandial, A. Chopra and B. Krishnamurthy, "Powering Virtual Try-On via Auxiliary Human Segmentation Learning," 2019 IEEE/CVF International Conference on Computer Vision Workshop (ICCVW), Seoul, Korea (South), 2019, pp. 3193-3196, doi:10.1109/ICCVW.2019.00397.

[3] N. Ramesh and T. Moh, "Outfit Recommender System," 2018 IEEE/ACM International Conference on Advances in Social Networks Analysis and Mining (ASONAM), Barcelona, 2018, pp. 903-910, doi: 10.1109/ASONAM.2018.8508656.

[4] X. Zeng, Y. Ding and S. Shao, "Applying Image Warping Technique to Implement Real-Time Virtual Try-On Based on Person's 2D Image," 2009 Second International Symposium on Information Science and Engineering, Shanghai, 2009, pp. 383-387, doi: 10.1109/ISISE.2009.9.

[5] C. Limaksornkul, D. N. Nakorn, O. Rakmanee and W. Viriyasitavat, "Smart Closet: Statistical-based apparel recommendation system," 2014 Third ICT International Student Project Conference (ICT-ISPC), Nakhon Pathom, 2014, pp. 155-158, doi: 10.1109/ICTISPC. 2014.6923240.

[6] N. Dwina, F. Arnia and K. Munadi, "Skin segmentation based on improved thresholding method," 2018 International ECTI Northern Section Conference on Electrical, Electronics, Computer and Telecommunications Engineering (ECTI-NCON), Chiang Rai, 2018, pp. 95-99, doi: 10.1109/ECTI-NCON.2018.8378289.

[7] Y. Wen, X. Liu and B. Xu, "Personalized Clothing Recommendation Based on Knowledge Graph," 2018 International Conference on Audio, Language and Image Processing (ICALIP), Shanghai, 2018, pp. 1-5, doi: 10.1109/ICALIP.2018.8455311.

[8] Y. Liu, Y. Gao, S. Feng and Z. Li, "Weather-to-garment: Weatheroriented clothing recommendation," 2017 IEEE International Conference on Multimedia and Expo (ICME), Hong Kong, 2017, pp. 181-186, doi: 10.1109/ICME.2017.8019476.